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SCIENCE

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Thomas Henry Huxley...on pure and applied science

"I often wish that this phrase, 'applied science,' had never been invented. For it suggests that there is a sort of scientific knowledge of direct practical use, which can be studied apart from another sort of scientific knowledge, which is of no practical utility, and which is termed 'pure science.' But there is no more complete fallacy than this. What people call applied science is nothing but the application of pure science to particular classes of problems. It consists of deductions from those general principles, established by reasoning and observation, which constitute pure science. No one can safely make these deductions until he has a firm grasp of the principles." —*Science and Culture*

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All Those In Favor

There is an important difference between the major bills for federal support of education now being considered by Congress and those that have been introduced in former years. In general—and of course there are exceptions—the major current bills emphasize improvement of quality, while earlier ones emphasized funds for school construction and for general purposes. Thus both the Administration bill and the Hill-Elliott bill (see analysis and comparison of these bills in *Science,* p. 389, 21 Feb. 1958) provide funds, in some cases with matching funds provided by the states, for the employment of additional teachers of science and mathematics or the improvement of salaries of teachers in these fields, for the employment of consultants or supervisors to improve teaching in science and mathematics, for help to teachers who wish to improve their knowledge of the subjects they are teaching, for the purchase of laboratory equipment, and for scholarships and fellowships for superior students.

Most of these provisions are of interest to the large number of scientists who are concerned with improving our educational system. Yet relatively few scientists have expressed their interest effectively as far as members of Congress are concerned. There are two easy explanations. First, only recently has general information concerning the major bills been widely available. Second, it is not the custom of the scientific community to "write to your Congressman." From the Congressman's standpoint, however, the lack of expression of interest means lack of interest. Members of Congress are quite ready to say that they depend to a considerable extent upon the voluntary expressions of interest and advice they receive from their constituents and that they find these expressions a useful guide in deciding what is desirable and what is wanted by the informed members of the public. In fact, several members of Congress have made it clear that they would like very much to receive more advice from persons who are well informed concerning educational and scientific matters.

At present, probably the most useful advice would concern general principles to be observed in legislation and the types of federal support that would be most desirable. There is not yet any bill ready for vote, and, for that matter, the bills that will be voted on have probably not yet been written. After the conclusion of hearings that are now being held, it is likely that the responsible committees will write new bills based upon those already submitted but modified on the basis of information and advice received during the hearings or in correspondence. When these bills have been written, it will be appropriate to express endorsement or criticism of specific bills or provisions of those bills.

The responsible committee in the Senate is the Committee on Labor and Public Welfare (Lister Hill, Ala.; James E. Murray, Mont.; Mathew M. Neely, W. Va.; John F. Kennedy, Mass.; Pat McNamara, Mich.; Wayne Morse, Ore.; Strom Thurmond, S.C.; H. Alexander Smith, N.J.; Irving M. Ives, N.Y.; William A. Purtell, Conn.; Barry Goldwater, Ariz.; Gordon Allott, Colo.; and John Sherman Cooper, Ky.), and in the House of Representatives, the Subcommittee on Education (Carl Elliott, Ala.; George S. McGovern, S.D.; Edith Green, Ore.; Stuyvesant Wainwright, N.Y.; and Donald W. Nicholson, Mass.). Letters, telegrams, or personal visits to any of these committee members, and, indeed, to any member of either House, would be appropriate and helpful.

Decisions in science are reached by a somewhat different method from decisions in Congress; hence the rules of the "scientific game" are quite different from those of the "Congressional game." But it is Congress that will enact legislation affecting science and education, and it is Congress that writes the rules for deciding on the legislation to be enacted. One of those rules is that persons who have an informed interest in proposed legislation are expected to tell Congress what they want.—D. W.

National Library Week—16-22 March 1958

Wake up and read! is the slogan of a nationwide campaign to increase the reading of books which will reach its climax during National Library Week, 16–22 March 1958. Sponsored jointly by the American Library Association and the National Book Committee ("a society of citizens devoted to the use of good books" founded in 1954), the campaign will stress the joys and profits of better reading. The AAAS, NEA, and many other national educational, cultural, and technical organizations have heartily endorsed this undertaking. State and local committees everywhere are active in promoting library open house, special exhibits, programs, and a myriad of other events and activities to focus attention in two directions, on the great wealth of good books flowing regularly from the presses and on the underutilized, and often inadequate, library resources in the United States.

A 1955 Gallup poll disclosed that 61 percent of American adults had not read a book, other than the Bible, during the previous year and that only 17 percent of those interviewed were reading a book at the time of the survey. From other surveys we learn that America is only one-third as literate as Great Britain and only one-fifth as literate as Sweden, in terms of adult book reading. We are told that one-half of American adults live within a mile of a public library, but only one-fifth of them ever enter it. Among American college students the situation is equally unpromising, for the average reading of this group is one book a month, and it is reported that many find it possible to complete a college curriculum without any reading other than assigned textbooks. Is the fact that only 12 percent of the homes constructed during the past decade have built-in bookshelves a clue? We think it is.

Two conferences on the development of lifetime reading habits, one with reference to secondary education held in June 1954, and one with reference to college undergraduates held at the University of Michigan 21–22 February 1958, disclosed that an inquiring mind and permanent interests in reading usually are developed initially in the home and supplemented by the resources of the community library. While some "converts" may be made of nonreaders during high school and college days, the percentage is small. If there are few or no books at home, and if the community and school libraries (where they do exist) are unattractive, poor in book resources, and uninspired in administration, then there is no climate for the growth of the will-to-know and the development of a lifetime companionship with books.

The AAAS, in cooperation with the National Science Foundation, has operated since the fall of 1955 an experimental traveling high school science library to encourage collateral reading in science and mathematics by high school students so that their perspectives might thereby be broadened and their interest in science careers stimulated. This program and its booklist have been very popular. The proportion of science and mathematics books in the libraries of schools applying for the program usually is quite small, and often the few books available are out of date. In many instances the annual amount appropriated for school library books is no more than the sum necessary to replace lost or worn-out books.

Let National Library Week turn our attention to our home library situation, to the improvement of the facilities and resources of our school and community libraries, and to the unprecedented wealth of good books now in print in the United States which should be used more widely and effectively.—Hilary J. Deason, *AAAS*.

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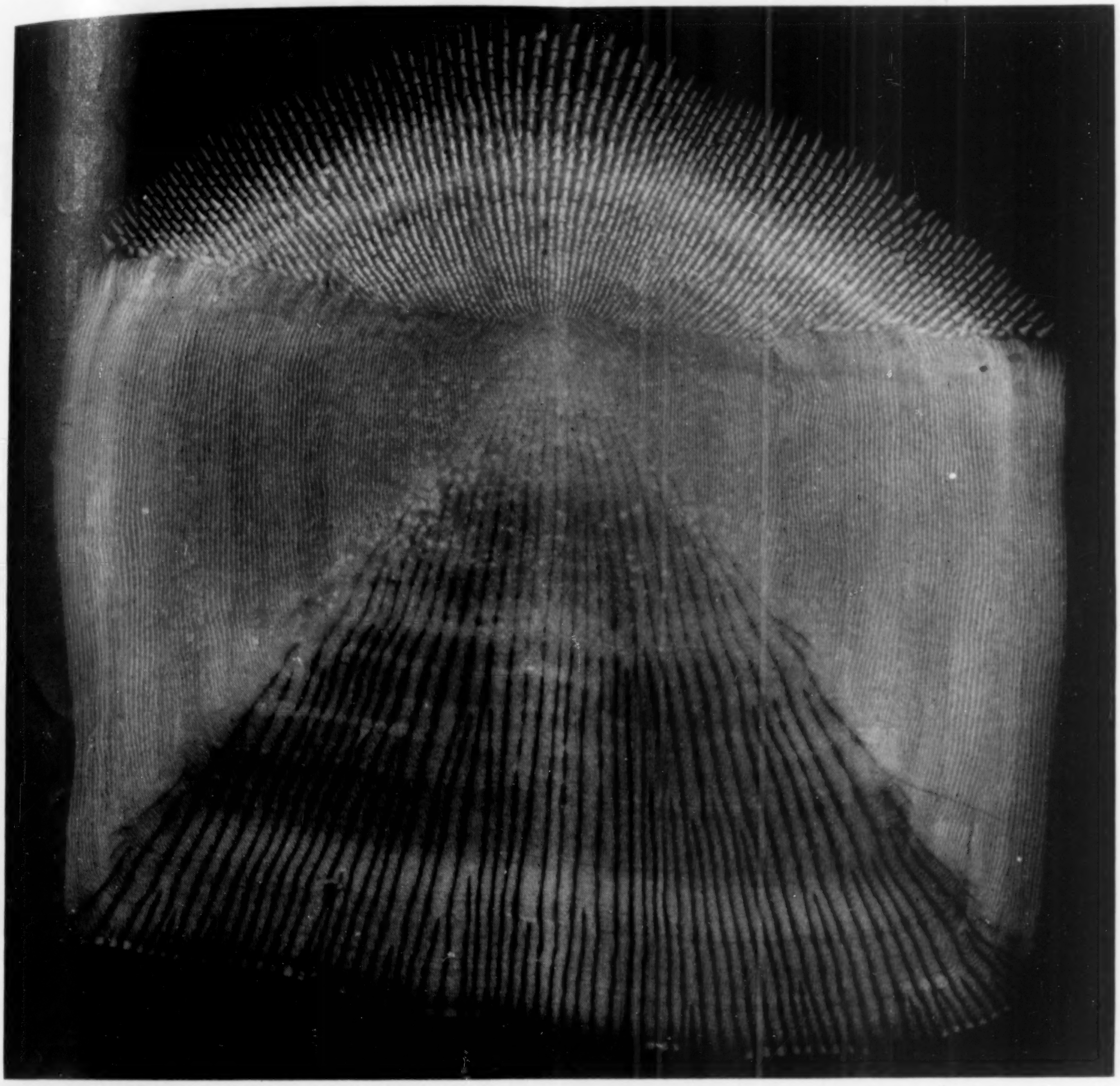

This is a microradiograph of a striped bass scale. In microradiography one passes low-voltage x-rays through a specimen to a special fine-grain photographic emulsion in intimate contact with it. The resulting photographic image then becomes a subject for conventional photographic enlargement or photomicrography. If you already know that much, there is then some point in requesting of Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y., information about an improved material for this work which we hope to have available in the near future. The same source can also provide a recently updated bibliography on results and techniques with microradiography.

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Law of Parity Conservation and Other Symmetry Laws

C. N. Yang

It is a pleasure and a great privilege to have this opportunity to discuss the question of parity conservation and other symmetry laws. We shall be concerned first with the general aspects of the role of the symmetry laws in physics, second, with the development that led to the disproof of parity conservation, and last, with a discussion of some other symmetry laws which physicists have learned through experience but which do not yet together form an integral and conceptually simple pattern. The interesting and very exciting developments since parity conservation was disproved will be covered by T. D. Lee in his lecture (*1*).

Symmetry Principles

The existence of symmetry laws is in full accordance with our daily experience. The simplest of these symmetries, the isotropy and homogeneity of space, are concepts that date back to the early history of human thought. The invariance of mechanical laws under a coordinate transformation of uniform velocity, also known as the invariance under Galilean transformations, is a more sophisticated symmetry that was early recognized and that formed one of the cornerstones of Newtonian mechanics. The consequences of these symmetry principles were greatly exploited by physicists of past centuries and gave rise to many important results. A good example in this direction is the theorem that in an isotropic solid there are only two elastic constants.

Another type of consequences of the symmetry laws relates to the conservation laws. It is common knowledge today that, in general, a symmetry principle (or, equivalently, an invariance principle) generates a conservation law. For example, the invariance of physical laws under space displacement has as a consequence the conservation of momentum, and the invariance under space rotation has as a consequence the conservation of angular momentum. While the importance of these conservation laws was fully understood, their close relationship with the symmetry laws does not seem to have been clearly recognized until the beginning of the 20th century (*2*) (see Fig. 1).

With the advent of special and general relativity, the symmetry laws gained new importance: Their connection with the dynamic laws of physics took on a much more integrated and interdependent relationship than in classical mechanics, where, logically, the symmetry laws were only consequences of the dynamical laws that, by chance, possess the symmetries. Also in the relativity theories the realm of the symmetry laws was greatly enriched to include invariances that were by no means apparent from daily experience. Their validity, rather, was deduced from or was later confirmed by complicated experimentation. Let me emphasize that the conceptual simplicity and intrinsic beauty of the symmetries that so evolve from complex experiments are, for the physicists, great sources of encouragement. One learns to hope that nature possesses an order that one may aspire to comprehend.

It was not, however, until the development of quantum mechanics that the use of the symmetry principles began to permeate into the very language of physics. The quantum numbers that designate the states of a system are often identical with those that represent the symmetries of the system. It indeed is scarcely possible to overemphasize the role played by the symmetry principles in quantum mechanics. To quote two examples: The general structure of the periodic table is essentially a direct consequence of the isotropy of Coulomb's laws. The existence of the antiparticles—namely, the positron, the antiproton, and the antineutron—were theoretically anticipated as consequences of the symmetry of physical laws with respect to Lorentz transformations. In both cases nature seems to take advantage of the simple mathematical representations of the symmetry laws. When one pauses to consider the elegance and the beautiful perfection of the mathematical reasoning involved and contrast it with the complex and far-reaching physical consequences, a deep sense of respect for the power of the symmetry laws never fails to develop.

One of the symmetry principles—the symmetry between the left and the right—is as old as human civilization. The question whether nature exhibits such symmetry was debated at length by philosophers in the past (*3*). Of course, in daily life, left and right are quite distinct from each other. Our hearts, for example, are always on our left sides. The language that people use, both in the Orient and the Occident, carries even a connotation that right is good and left is evil. However, the laws of physics have always shown complete symmetry between the left and the right, the asymmetry in daily life being attributed to the accidental asymmetry of the environment, or to the initial conditions in organic life. To illustrate the point, I

Dr. Yang is a professor of physics at the Institute for Advanced Study, Princeton, N.J. This article is the lecture which he delivered in Stockholm, Sweden, on 11 Dec. 1957, when he was awarded the Nobel prize in physics, a prize which he shared with Tsung-Dao Lee. The lecture is published with the permission of the Nobel Foundation. Dr. Lee's Nobel lecture also appears in this issue.

might mention that if there existed a mirror-image man with his heart on his right side, his internal organs reversed as compared with ours, and in fact his body molecules (for example sugar molecules) the mirror image of ours, and if he ate the mirror image of the food that we eat, then according to the laws of physics, he should function as well as we do.

The law of right-left symmetry was used in classical physics but was not of any great practical importance there. One reason for this derives from the fact that right-left symmetry is a discrete symmetry, unlike rotational symmetry which is continuous. Whereas, in classical mechanics, the continuous symmetries always led to conservation laws, a discrete symmetry does not. With the introduction of quantum mechanics, however, this difference between the discrete and continuous symmetries disappears. The law of right-left symmetry then leads also to a conservation law: the conservation of parity.

The discovery of this conservation law dates back to 1924, when Laporte (4) found that energy levels in complex atoms can be classified into "*gestrichene*" and "*ungestrichene*" types, or, in more recent language, even and odd levels. In transitions between these levels during which one photon is emitted or absorbed, Laporte found that the level always changes from even to odd or vice versa. Anticipating later developments, we remark that the evenness or oddness of the levels was later referred to as the parity of the levels. The even levels are defined as having parity +1, the odd levels, parity −1. One also defines the photon emitted or absorbed in the usual atomic transitions as having odd parity. Laporte's rule can then be formulated as the statement that, in an atomic transition, with the emission of a photon, the parity of the initial state is equal to the total parity of the final state—that is, the product of the parities of the final atomic state and the photon emitted. In other words, parity is conserved, or unchanged, in the transition.

In 1927 Wigner (5) took the critical and profound step of proving that the empirical rule of Laporte is a consequence of the reflection invariance, or right-left symmetry, of the electromagnetic forces in the atom. This fundamental idea was rapidly absorbed into the language of physics. Since right-left symmetry was unquestioned also in other interactions, the idea was further taken over into new domains as the subject matter of physics extended into nuclear reactions, β-decay, meson interactions, and strange particle physics. One became accustomed to the idea of nuclear parities as well as to that of atomic parities, and one discusses and measures the intrinsic parities of the mesons. Throughout these developments, the concept of parity and the law of parity conservation proved to be extremely fruitful, and the success was, in turn, taken as a support for the validity of right-left symmetry.

Table 1. Classes and strengths of interactions.

Class	Strength
1. Nuclear forces	1
2. Electromagnetic forces	10^{-2}
3. Weak forces (decay interactions)	10^{-13}
4. Gravitational forces	10^{-38}

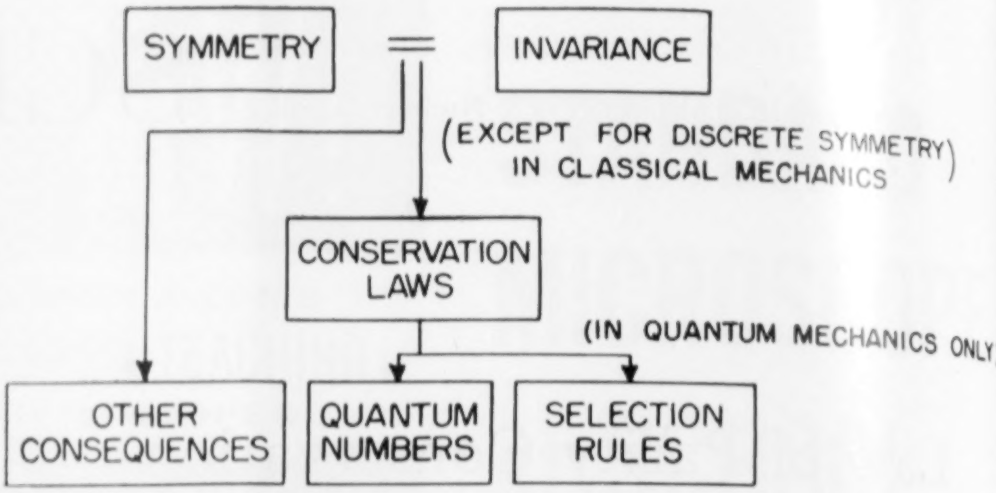

Fig. 1. Relationship between conservation laws and symmetry laws.

Theta-Tau Puzzle

Against such a background the so-called θ–τ puzzle developed in the last few years. Before I explain the meaning of this puzzle it is best to go a little bit into a classification of the forces that act between subatomic particles, a classification which the physicists have learned through experience to use in the last 50 years. The four classes of interactions, together with their strengths, are listed in Table 1.

The strongest interactions are the nuclear interactions, which include the forces that bind nuclei together and the interactions between the nuclei and the π mesons. These also include the interactions that give rise to the observed strange particle production. The interactions of the second class are the electromagnetic interactions, about which physicists know a great deal. In fact, the crowning achievement of the physicists of the 19th century was a detailed understanding of the electromagnetic forces. With the advent of quantum mechanics, our understanding of electromagnetic forces gave, in principle, an accurate, integral, and detailed description of practically all the physical and chemical phenomena of our daily experience. The third class of forces, the weak interactions, was first discovered around the beginning of this century in the β-radioactivity of nuclei—a phenomenon which, especially in the last 25 years, has been extensively studied experimentally. With the discovery of π-μ, μ-*e* decays and μ capture, it was noticed independently by Klein, by Tiomno and Wheeler, and by Lee, Rosenbluth, and me (6) that these interactions have roughly the same strengths as β-interactions. They are called weak interactions, and in the last few years their rank has been constantly added to through the discovery of many other weak interactions responsible for the decay of the strange particles. The consistent and striking pattern of their almost uniform strength remains today one of the most tantalizing phenomena—a topic which we shall come back to later. About the last class of forces, the gravitational forces, we need only mention that in atomic and nuclear interactions they are so weak as to be completely negligible in all observations made with existing techniques.

Now to return to the θ–τ puzzle. In 1953 Dalitz and Fabri (7) pointed out that, in the decay of the θ and τ mesons,

$$\theta \rightarrow \pi + \pi$$

$$\tau \rightarrow \pi + \pi + \pi$$

some information about the spins and parities of the τ and θ mesons can be obtained. The argument is, very roughly, as follows. It has previously been determined that the parity of a π meson is odd (that is, equals −1). Let us first neglect the effects due to the relative motion of the π-mesons. To conserve parity in the decays, the θ meson must have the total parity or, in other words, the product parity, of two π mesons, which is even (that is, equals +1). Similarly, the τ meson must have the total parity of three π-mesons, which is odd. Actually, because of the relative motion of the π-mesons, the argument was not as simple and unambiguous as here set forth. To render the argument conclusive and definitive, it was necessary to study experimentally the momentum and angular distribution of the π mesons. Such studies were made in many laboratories, and by the spring of 1956 the accumulated experimental data seemed to indicate unambiguously, along the lines of reasoning discussed above, that θ and τ do not have the same parity and, consequently, that they are not the same particle. This conclusion, however, was in marked contradiction to other experimental results which also became definite at about the same time. The contradiction was known as the "θ–τ puzzle" and was widely discussed. To recapture the atmosphere of that time, I shall quote a paragraph concerning the conclusion that θ and τ are not the same particle from a report, entitled "Present knowledge about the new particles," which I gave at the International Conference on Theoretical Physics in Seattle, Washington, in September 1956 (*8*):

"However it will not do to jump to hasty conclusions. This is because experimentally the *K* mesons [that is, τ and θ] seem all to have the same masses and the same lifetimes. The masses are known to an accuracy of, say, from 2 to 10 electron masses, or a fraction of a percent, and the lifetimes are known to an accuracy of, say, 20 percent. Since particles which have different spin and parity values, and which have strong interactions with the nucleons and pions, are not expected to have identical masses and lifetimes, one is forced to keep the question open whether the inference mentioned above that the τ and θ are not the same particle is conclusive. *Parenthetically, I might add that the inference would certainly have been regarded as conclusive, and in fact more well founded than many inferences in physics, had it not been for the anomaly of mass and lifetime degeneracies.*"

The situation that the physicist found himself in at that time has been likened to that of a man in a dark room groping for an outlet. He is aware of the fact that in some direction there must be a door which would lead him out of his predicament. But in which direction?

That direction, it turned out, lay in the faultiness of the law of parity conservation for the weak interactions. But to uproot an accepted concept one must first demonstrate why the previous evidences in its favor are insufficient. T. D. Lee and I (*9*) examined this question in detail, and in May 1956 we came to the following conclusions. (i) Past experiments on the weak interactions had actually no bearing on the question of parity conservation. (ii) In the strong interactions—that is, interactions of classes 1 and 2 (Table 1)—there were indeed many experiments that established parity conservation to a high degree of accuracy, but not to a sufficiently high degree to be able to reveal the effects of a lack of parity conservation in weak interactions.

The fact that it was believed for so long, without experimental support, that the law of parity conservation held good for the weak interactions, was very startling. But what was more startling was the prospect that a space-time symmetry law, which the physicists have learned so well, may be violated. This prospect did not exactly appeal to us. Rather, we were, so to speak, driven to it through frustration in the various other efforts at understanding the θ–τ puzzle that had been made (*10*).

As I shall mention later, there is known in physics a conservation law—the conservation of isotopic spin—that holds for interactions of class 1 but breaks down when weaker interactions are introduced. Such a possibility of an approximate symmetry law was, however, not expected of the symmetries related to space and time. In fact, one is tempted to speculate, now that parity conservation has been found to be violated in the weak interactions, whether in the description of the weak interactions the usual concept of space and time is adequate. At the end of this discussion I shall have occasion to come back to a closely related topic.

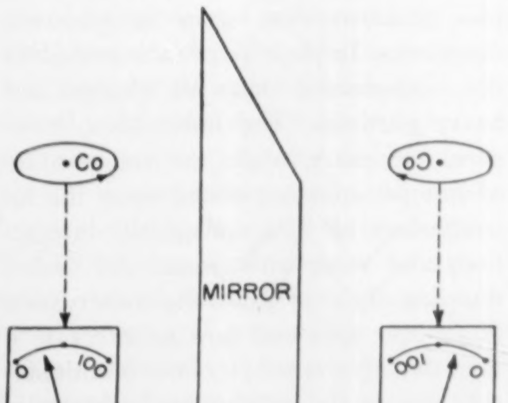

Fig. 2. Schematic diagram of experiment to test parity conservation in β-decay.

Why was it the case that among the multitude of experiments on β-decay—the most exhaustively studied of all the weak interactions—there was no information on the conservation of parity in the weak interactions? The answer derives from a combination of two reasons. First, the fact that the neutrino does not have a measurable mass introduces an ambiguity that rules out (*11*) indirect information on parity conservation from such simple experiments as the spectrum of β-decay. Second, to study directly parity conservation in β-decay, it is not enough to discuss nuclear parities, as one had always done. One must study parity conservation of the *whole* decay process. In other words, one must design an experiment that tests right-left symmetry in the decay. Such experiments had not been made.

Test of Parity Conservation in the Weak Interactions

Once these points were understood, it was easy to point out what were the experiments that would unambiguously test the previously untested assumption of parity conservation in the weak interactions. T. D. Lee and I proposed (*9*), in the summer of 1956, a number of such tests concerning β-decay, π-μ, μ-*e* and strange particle decays. The basic principles involved in these experiments are all the same: *One constructs two sets of experimental arrangements which are mirror images of each other, and which contain weak interactions. One then examines whether the two arrangements always give the same results in terms of the readings of their meters* (or counters). If the results are not the same, one has an unequivocal proof that right-left symmetry, as we usually understand it, breaks down. The idea is illustrated in Fig. 2, which shows the experiment proposed to test parity conservation in β-decay.

This experiment was first performed in the latter half of 1956, and was finished early in 1957, by Wu, Ambler, Hayward, Hoppes, and Hudson (*12*). The actual experimental setup was very involved, because to eliminate disturbing outside influences, the experiment had to be made at very low temperatures. The technique of combining a measurement of β-decay with low-temperature apparatus had not been known before and constituted a major difficulty, which was successfully solved by these authors. To their courage and their skill physicists owe the exciting and clarifying developments of the past year concerning parity conservation.

As a result of their experiment, Wu, Ambler, and their collaborators found that there is a very large difference in the readings of the two meters illustrated schematically in Fig. 2. Since the behavior of the other parts of their apparatus observes right-left symmetry, the asymmetry that was found must be attributed to the β-decay of cobalt. Very rapidly after these results were made known, many experiments were performed which further demonstrated the violation of parity conservation in various weak interactions (*1*).

Discussion

The breakdown of parity conservation brings into focus a number of questions concerning symmetry laws in physics which I shall now briefly discuss in general terms:

1) The experiment of Wu, Ambler, and their collaborators also proves (*13, 14*) that charge conjugation invariance (*15*) is violated for β-decay. Another symmetry, called time-reversal invariance (*16*), is at the present moment still being experimentally studied for the weak interactions.

The three discrete invariances—reflection invariance, charge conjugation invariance, and time-reversal invariance—are connected by an important theorem (*17, 18*), called the CPT theorem. Through the use of this theorem one can prove (*13*) a number of general results concerning the experimental manifestations of the possible violations of the three symmetries in the weak interactions.

Of particular interest is the possibility that time-reversal invariance in the weak interactions may turn out to be intact. If this is the case, it follows from the CPT theorem that, although parity conservation breaks down, right-left symmetry will still hold if (*19*) one switches all particles into antiparticles in taking a mirror image. In terms of Fig. 2, this means that if one changes *all* the matter that composes the apparatus at the right into antimatter, the meter reading would become the same for the two sides if time-reversal invariance holds. It is important to notice that, in the usual definition of reflection, the electric field is a vector and the magnetic field a pseudovector, while in this changed definition their transformation properties are switched. The transformation properties of the electric charge and the magnetic charge are also interchanged. It would be interesting to speculate on the possible relationship between the nonconservation of parity and the symmetrical or unsymmetrical role played by the electric and magnetic fields.

The question of the validity of the continuous space-time symmetry laws has been discussed to some extent in the past year. There is good evidence that these symmetry laws do not break down in the weak interactions.

2) Another symmetry law that has been widely discussed is that giving rise to the conservation of isotopic spin (*20*). In recent years the use of this symmetry law has produced a remarkable empirical order among the phenomena concerning the strange particles (*21*). It is, however, certainly the least understood of all the symmetry laws. Unlike Lorentz invariance or reflection invariance, it is not a "geometrical" symmetry law relating to space-time invariance properties. Unlike charge conjugation invariance (*18*) it does not seem to originate from the algebraic property of the complex numbers that occur in quantum mechanics. In these respects it resembles the conservation laws of charge and heavy particles. The latter laws, however, are exact, while the conservation of isotopic spin is violated upon the introduction of electromagnetic interactions and weak interactions. An understanding of the origin of the conservation of isotopic spin and how to integrate it with the other symmetry laws is undoubtedly one of the outstanding problems in high-energy physics today.

3) I have mentioned before that all the different varieties of weak interactions share the property of having very nearly identical strengths. The experimental work on parity nonconservation in the past year reveals that they very probably also share the property of not respecting parity conservation and charge conjugation invariance. They therefore serve to differentiate between right and left once one fixes one's definition of matter versus antimatter. One could also use the weak interactions to differentiate between matter and antimatter once one chooses a definition of right versus left. If time-reversal invariance is violated, the weak interactions may even serve to differentiate simultaneously right from left and matter from antimatter. One senses herein that the origin of the weak interactions may be intimately tied in with the question of the differentiability of left from right and of matter from antimatter.

References and Notes

1. T. D. Lee, Nobel lecture, 11 Dec. 1957; *Science*, this issue.
2. For references to these developments, see E. P. Wigner, *Proc. Am. Phil. Soc.* 93, 521 (1949).
3. Compare the interesting discussion on bilateral symmetry by H. Weyl [*Symmetry* (Princeton Univ. Press, 1952)].
4. O. Laporte, *Z. Physik* 23, 135 (1924).
5. E. P. Wigner, *ibid.* 43, 624 (1927).
6. O. Klein, *Nature* 161, 897 (1948); J. Tiomno and J. A. Wheeler, *Revs. Modern Phys.* 21, 144 (1949); T. D. Lee, M. Rosenbluth, C. N. Yang, *Phys. Rev.* 75, 905 (1949).
7. R. Dalitz, *Phil. Mag.* 44, 1068 (1953); E. Fabri, *Nuovo Cimento* 11, 479 (1954).
8. C. N. Yang, *Revs. Modern Phys.* 29, 231 (1957).
9. T. D. Lee and C. N. Yang, *Phys. Rev.* 104, 254 (1956).
10. T. D. Lee and J. Orear, *ibid.* 100, 932 (1955); T. D. Lee and C. N. Yang, *ibid.* 102, 290 (1956); M. Gell-Mann, unpublished; R. Weinstein, private communication. A general discussion of these ideas can be found in the *Proceedings of the Rochester Conference (April 1956)*, (Interscience, New York, 1957), session VIII.
11. C. N. Yang and J. Tiomno, *Phys. Rev.* 79 495 (1950).
12. C. S. Wu, E. Ambler, R. W. Hayward, D. D. Hoppes, R. P. Hudson, *ibid.* 105, 1413 (1957).
13. T. D. Lee, R. Oehme, C. N. Yang, *ibid.* 106, 340 (1957).
14. B. L. Ioffe, L. B. Okun', A. P. Rudik, *J. Exptl. Theoret. Phys.* (*U.S.S.R.*) 32, 396 (1957); English translation in *Soviet Phys. JETP* 5, 328 (1957).
15. Charge conjugation invariance is very intimately tied with the hole theory interpretation of Dirac's equation. The development of the latter originated with P. A. M. Dirac. [*Proc. Roy. Soc.* (*London*) 126A, 360 (1930)], J. R. Oppenheimer [*Phys. Rev.* 35, 562 (1930)], and H. Weyl [*Gruppen theorie und Quantenmechanik* (ed. 2, 1931), p. 234]. An account of these developments is found in P. A. M. Dirac, *Proc. Roy. Soc.* (*London*) 133A, 60 (1931). Detailed formalism and application of charge conjugation invariance started with H. A. Kramers [*Proc. Acad. Sci. Amsterdam* 40, 814 (1937)] and W. Furry [*Phys. Rev.* 51, 125 (1937)].
16. E. P. Wigner, *Nachr. Akad. Wiss. Göttingen, Math.-physik. Kl.* 1932, 546 (1932). This paper explains in terms of time-reversal invariance the earlier work of H. Kramers [*Proc. Acad. Sci. Amsterdam* 33, 959 (1930)].
17. J. Schwinger, *Phys. Rev.* 91, 720, 723 (1953); G. Lüders, *Kgl. Danske Videnskab. Selskab, Mat–fys. Medd.* 28 (1954); W. Pauli's article in *Niels Bohr and the Development of Physics* (Pergamon, London, 1955).
18. R. Jost, *Helv. Phys. Acta* 30, 409 (1957).
19. This possibility was discussed by T. D. Lee and me and reported by me at the International Conference on Theoretical Physics in Seattle, Washington, in September 1956 (see 8). Its relation with the CPT theorem was

also reported at the same conference in one of the discussion sessions. The speculation was later published in T. D. Lee and C. N. Yang, *Phys. Rev.* 105, 1671 (1957). Independently, the possibility has been advanced as the correct one by L. Landau, *J. Exptl. Theoret. Phys. (U.S.S.R.)* 32, 405 (1957). An English translation of Landau's article appeared in *Soviet Phys. JETP* 5, 336 (1957).
20. The concept of a total isotopic spin quantum number was first discussed by B. Cassen and E. U. Condon [*Phys. Rev.* 50, 846 (1936)] and E. P. Wigner [*Phys. Rev.* 51, 106 (1937)]. The physical basis derived from the equivalence of *p-p* and *n-p* forces, as pointed out by G. Breit, E. U. Condon, and R. D. Present [*Phys. Rev.* 50, 825 (1936)]. The isotopic spin was introduced earlier as a formal mathematical parameter by W. Heisenberg [*Z. Physik* 77, 1 (1932)].
21. A. Pais [*Phys. Rev.* 86, 663 (1952)] introduced the idea of associated production of strange particles. An explanation of this phenomenon in terms of isotopic spin conservation was pointed out by M. Gell-Mann [*Phys. Rev.* 92, 833 (1953)] and by K. Nishijima [*Progr. Theoret. Phys.* (*Kyoto*) 12, 107 (1954)]. These latter authors also showed that isotopic spin conservation leads to a convenient quantum number called "strangeness."

Weak Interactions and Nonconservation of Parity

T. D. Lee

In the previous lecture C. N. Yang (*1*) has outlined the position of our understandings concerning the various symmetry principles in physics prior to the end of 1956. Since then, in the short period of one year, the proper roles of these principles in various physical processes have been greatly clarified. This remarkably rapid development was made possible only through the efforts and ingenuities of many physicists in various laboratories all over the world. To have a proper perspective and understanding of these new experimental results, it may be desirable to review very briefly our knowledge about elementary particles and their interactions.

Elementary Particles and Their Interactions

The family of elementary particles that we know today consists of numerous members. Each member is characterized, among other properties, by its mass, charge, and spin. These members are separated into two main groups, the "heavy-particle" group and the "light-particle" group. The well-known examples of heavy particles are protons and neutrons, of light particles, photons and electrons. Apart from the obvious implication that a heavy particle is heavier than a light particle, this classification stems from the observation that a single heavy particle cannot disintegrate into light particles even if such disintegration should be compatible with the conservation laws of charge, energy, momentum, and angular momentum. This fact is more precisely formulated as the "law of conservation of heavy particles," which states that if to each heavy particle we assign a heavy particle number +1, to each antiheavy particle a heavy particle number −1, and to each light particle a corresponding number 0, then in all known physical processes the algebraic sum of the heavy particle numbers is absolutely conserved. One of the simplest evidences of the validity of this law is the fact that we, or our galaxy, have not disintegrated into radiation and other light particles.

Figure 1 shows all the known heavy particles (and antiheavy particles). All heavy particles except the nucleons are called hyperons and are labeled by capital Greek letters. The solid lines represent particles that have already been observed, while the dotted lines represent particles that are expected to exist from general theoretical arguments. All known heavy particles have half-integral spins. Figure 2 shows all the known light particles. Among these, the $e^\pm$, $\mu^\pm$ and ν, $\bar{\nu}$ have half-integral spins. They are called leptons. The rest—photons, pions, and K-mesons—have integral spins.

The interactions (not including the gravitational forces) between these particles can be classified into three distinct groups.

1) *Strong interactions.* This group is responsible for the production and the scattering of nucleons, pions, hyperons (that is, Λ^0, Σ^-, and so forth), and K-mesons. It is characterized by a coupling constant $f^2/\hbar c \cong 1$.

2) *Electromagnetic interactions.* The electromagnetic coupling constant is $e^2/\hbar c = 1/137$.

3) *Weak interactions.* This group includes all known nonelectromagnetic decay interactions of these elementary particles and the recently observed absorption process of neutrinos by nucleons (*2*). These interactions are characterized by coupling constants $g^2/\hbar c \cong 10^{-14}$.

The law of conservation of parity is valid for both the strong and the electromagnetic interactions but is not valid for the weak interactions. This discussion will be mainly concerned with the recently observed effects of nonconservation of parity in the various weak interactions.

Noninvariance under Mirror Reflection and Charge Conjugation

The weak interactions cover a large variety of reactions. At present there are about twenty known phenomenologically independent reactions ranging from the decay of various hyperons to the decay of light particles. Within the last year, many critical experiments have been performed to test the validity of the law of conservation of parity in these reactions. We shall first summarize the experimental results together with their direct theoretical implications. Next, we shall discuss some further possible consequences and theoretical considerations.

β-Decay. The first experiment that conclusively established the nonconservation of parity was that on β-angular distribution from polarized cobalt-60 nuclei (*3*) (Fig. 3). The cobalt-60 nuclei are polarized by a magnetic field at very low temperatures. Indeed, in this experi-

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ment, the circular direction of the electric current in the solenoid that produces the polarizing magnetic field, together with the preferential direction of the β-ray emitted, differentiates in a very direct way a right-handed system from a left-handed system. Thus the nonconservation of parity or the noninvariance under a mirror reflection can be established without reference to any theory.

Furthermore, from the large amount of angular asymmetry observed, it can also be established (*4*) that the β-decay interaction is not invariant under a charge conjugation operation. That this can be concluded without performing the extremely difficult (in fact, almost impossible) experiment using anticobalt-60 is based on certain theoretical deductions under the general framework of local field theory. In the following we shall try to sketch this type of reasoning (*5*).

Let us consider the β-decay process, say,

$$n \rightarrow p + e^- + \nu, \qquad (1)$$

in which each particle is described by a quantized wave equation. In particular the neutrino is described by the Dirac equation (*6*)

$$\sum_{\mu=1}^{4} \gamma_\mu \frac{\partial}{\partial x_\mu} \psi_\nu = 0, \qquad (2)$$

where γ_1, γ_2, γ_3, γ_4 are the four (4×4) anticommuting Dirac matrices and x_1, x_2, x_3, $x_4 = ict$ are the four space-time coordinates. For each given momentum there exist two spin states for the neutrino and two spin states for the antineutrino. These may be denoted by ν_R, ν_L, $\bar{\nu}_R$, $\bar{\nu}_L$. If we define the helicity $\mathcal{H}$ to be

$$\mathcal{H} \equiv \vec{\sigma} \cdot \hat{p}, \qquad (3)$$

with $\vec{\sigma}$ as the spin operator and $\hat{p}$ the unit vector along the momentum direction, then these four states have, respectively, helicities equal to $+1$, -1, -1 and $+1$ (Fig. 4). Mathematically, this decomposition of states corresponds to a separation of ψ_ν into a right-handed part ψ_R and a left-handed part ψ_L with

$$\psi_\nu = \psi_R + \psi_L, \qquad (4)$$

where

$$\psi_R = \tfrac{1}{2}(1 - \gamma_5)\psi_\nu, \qquad (5)$$

$$\psi_L = \tfrac{1}{2}(1 + \gamma_5)\psi_\nu, \qquad (6)$$

and

$$\gamma_5 = \gamma_1\gamma_2\gamma_3\gamma_4$$

It is easy to see that both ψ_R and ψ_L separately satisfy the Dirac equation (Eq. 2). With this decomposition the β process of a nucleus A can be represented schematically as

$$A \rightarrow B + e^- + \begin{cases} C_i^R \nu_R & (\mathcal{H} = +1) \quad (7) \\ C_i^L \nu_L & (\mathcal{H} = -1) \quad (8) \end{cases}$$

with C_i^R and C_i^L as the various probability amplitudes for emission of ν_R and ν_L, respectively. The suffix i represents the various possible channels for such emissions. If the theory is invariant under proper Lorentz transformation, then there are five such channels: namely scalar S, tensor T, vector V, pseudoscalar P and axial-vector term A. According to the general rules of quantum field theory with any interaction term representing the decay of a particle, there exists a corresponding hermitian conjugate term which represents the decay of the antiparticle. Thus, the decay of the antinucleus $\bar{A}$ can be schematically represented by

$$\bar{A} \rightarrow \bar{B} + e^+ + \begin{cases} C_i^{R*} \bar{\nu}_R & (\mathcal{H} = -1) \quad (7') \\ C_i^{L*} \bar{\nu}_L & (\mathcal{H} = +1) \quad (8') \end{cases}$$

with C_i^{R*} and C_i^{L*} as the corresponding amplitudes for emission of $\bar{\nu}_R$ and $\bar{\nu}_L$. Under the charge conjugation operator we change a particle to its antiparticle but we do not change its spatial or spin wave functions. Consequently, it must have the same helicity. Thus, if the β-decay process is invariant under the charge conjugation operator, then we should expect process 7 to proceed with the same amplitude as process 8′. The condition for invariance under charge conjugation is, then,

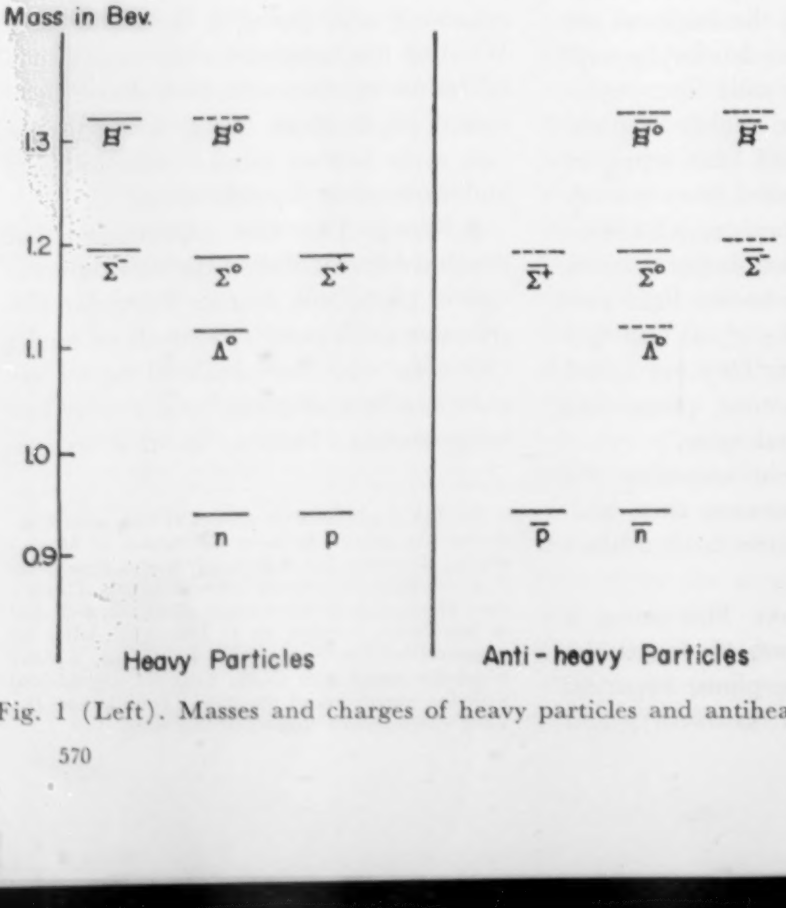
$$C_i^R = C_i^{L*} \qquad (9)$$

for all $i = $ S, T, V, P, A.

In the decay of cobalt-60, because there is a difference of spin values between cobalt-60 and nickel-60, only the terms $i = $ T and $i = $ A contribute. From the large angular asymmetry observed it can be safely concluded that for both $i = $ T, A

$$|C_i^R| \neq |C_i^L|$$

which contradicts Eq. 9 and proves the noninvariance of β-interaction under charge conjugation. In the above, for illustration purposes, we assume the neu-



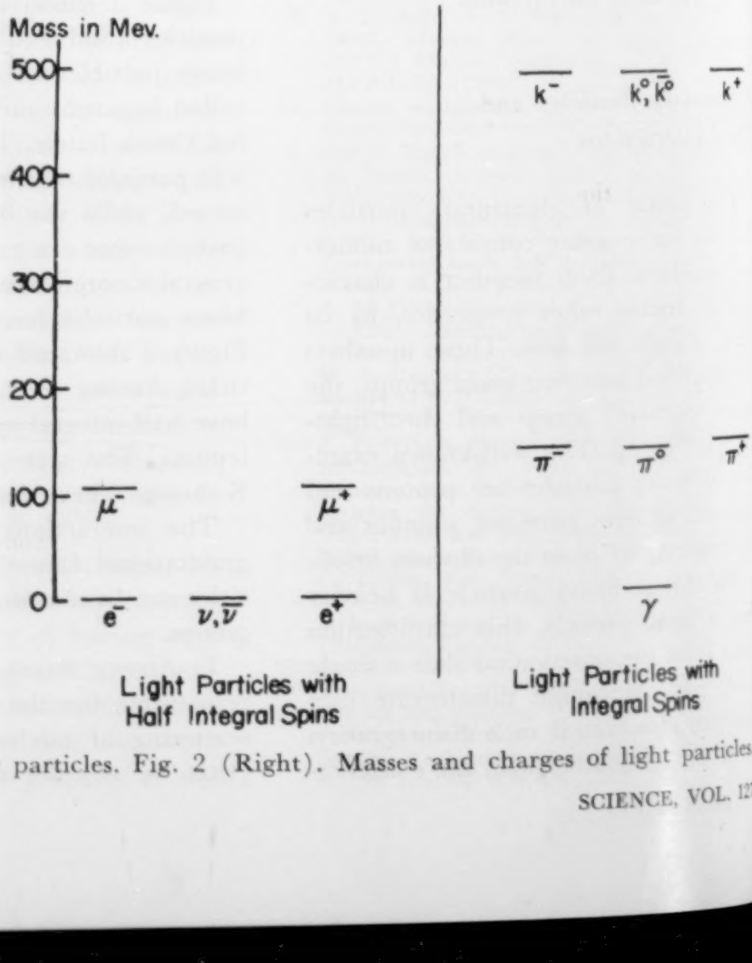


Fig. 1 (Left). Masses and charges of heavy particles and antiheavy particles. Fig. 2 (Right). Masses and charges of light particles.

trino to be described by a four-component theory and, further, we assume that in the β-decay process only a neutrino is emitted. Actually, the same conclusion concerning the noninvariance property under charge conjugation can be obtained even if the neutrino should be described by a, say, eight-component theory, or, if in addition to the β-process that a neutrino is produced an antineutrino may also be emitted.

Recently many more experiments (7) have been performed on the longitudinal polarization of electrons and positrons, the β-γ correlation together with the circular polarization of the γ radiation and the β-angular distribution with various polarized nuclei other than cobalt-60. The results of all these experiments confirm the main conclusions of the first cobalt-60 experiment, that neither the parity operator nor the charge conjugation operator is conserved in β-decay processes.

Another interesting question is whether the β-decay interaction is invariant under the product operation of (charge conjugation × mirror reflection). Under such an operation we should compare the decay of A with that of $\overline{A}$ but with opposite helicities. Thus, if β-decay is invariant under the joint operation of (charge conjugation × mirror reflection) we should expect process 7 to proceed with the same amplitude as process 7′ and similarly for processes 8 and 8′. The corresponding conditions are then

$$C_i^{R} = C_i^{R*},$$

and

$$C_i^{L} = C_i^{L*}. \tag{10}$$

Although experiments have been performed to test the validity of these conditions, at present these experiments have not reached a conclusive stage and we still do not know the answer to this important question.

π-μ-e Decay. The $\pi^{\pm}$-meson decays into a $\mu^{\pm}$-meson and a neutrino. The $\mu^{\pm}$-meson, in turn, decays into an $e^{\pm}$ and two neutrinos (or antineutrinos). If parity is not conserved in π-decay, the μ-meson emitted could be longitudinally polarized. If in the subsequent μ-decay parity is also not conserved, the electron (or positron) emitted from such a μ-meson at rest would in general exhibit a forward and backward angular asymmetry with respect to the polarization of the μ-meson (Fig. 5). Consequently, in the π-μ-e decay sequence we may observe an angular correlation between the momentum of a $\mu^{\pm}$-meson measured in the rest system of a π-meson and the momentum of $e^{\pm}$ measured in the rest system of $\mu^{\pm}$. If this angular correlation shows a forward-backward asymmetry, then parity must be nonconserved in both π-decay and μ-decay. The experimental results (8) on these angular correlations appeared within a few days after the results on β-decay were known. These results showed conclusively that not only is parity not conserved but that the charge conjugation operator is also not conserved in π-decay as well as in μ-decay.

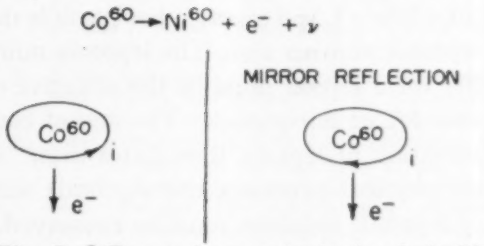


Fig. 3. β-Decay from polarized cobalt-60 nucleus.

Later, direct measurements (9) on the longitudinal polarization of the positron from μ^{+}-decay were made and established the same conclusion concerning μ-decay.

K-μ-e Decay. In this case we have instead of the π-meson the heavier K-meson which decays into a μ-meson and a neutrino (Fig. 6). An experiment (10) on the angular correlation between the μ^{+} momentum from the decay of a K^{+}-meson and the positron momentum from the μ^{+}-decay established that in K-decay the parity as well as the charge conjugation operator is not conserved.

Λ° Decay. The Λ° particle can be produced by colliding an energetic π^{-} on a proton. The Λ° subsequently decays into a proton plus a π^{-} (Fig. 7). The observation of an asymmetrical distribution with respect to the sign of the product $\vec{p}_{\text{out}} \cdot (\vec{p}_{\text{in}} \times \vec{p}_{\Lambda})$ formed from the momentum of the incoming pion $\vec{p}_{\text{in}}$, the momentum of the lambda particle, $\vec{p}_{\Lambda}$, and that of the decay pion $\vec{p}_{\text{out}}$ would constitute an unequivocal proof that parity is not conserved in this decay. Recent experiments (11) on these reactions demonstrate that in these reactions there is indeed such an angular correlation between $\vec{p}_{\text{out}}$ and $(\vec{p}_{\text{in}} \times \vec{p}_{\Lambda})$. Furthermore, from the amount of the large up-down asymmetry, it can be concluded that the Λ°-decay interaction is also not invariant under the charge conjugation operation.

From all these results it appears that the property of nonconservation of parity in the various weak interactions and that the noninvariance property of these interactions under charge conjugation are well established. In connection with these properties we find an entirely new and rich domain of natural phenomena which, in turn, give us new tools to probe further into the structure of our physical world. These weak interactions offer us natural ways to polarize and to analyze the spins of various elementary particles. Thus, for example, the magnetic moment of the μ-meson can now be measured to an extremely high degree of accuracy (12) which, otherwise, would be unattainable; the spins of some hyperons now may perhaps be determined (13) unambiguously through the observed angular asymmetries in their decays; new aspects of the electromagnetic fields of various gas, liquid, and solid materials can now be studied by using these unstable, polarized particles. However, perhaps the most significant consequences are the openings of new possibilities and the reexamination of our old concepts concerning the structure of elementary particles. We shall next discuss two such considerations—the two-component theory of the neutrino and the possible existence of a law of conservation of leptons.

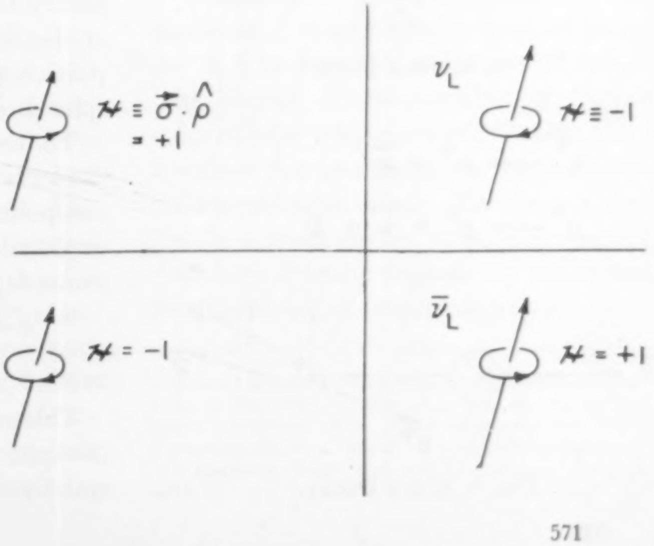


Fig. 4. Helicities of a four-component neutrino.

Two-Component Theory of Neutrino and Law of Conservation of Leptons

Before the recent developments on nonconservation of parity, it was customary to describe the neutrino by a four-component theory in which, as mentioned before, to each definite momentum there are the two spin states of the neutrino ν_R and ν_L, plus the two spin states of the antineutrino $\bar{\nu}_R$ and $\bar{\nu}_L$. In the two-component theory, however, we assume that two of these states, say ν_L and $\bar{\nu}_L$, simply do not exist in nature. The spin of the neutrino is then always parallel to its momentum, while the spin of the antineutrino is always antiparallel to its momentum. Thus, in the two-component theory we have only half of the degrees of freedom that we have in the four-component theory. Graphically, we may represent the spin and the velocity of the neutrino by the spiral motion of a right-handed screw and that of the antineutrino by the motion of a left-handed screw (Fig. 8).

The possibility of a two-component relativistic theory of a spin ½ particle was first discussed by H. Weyl (*14*) as early as 1929. However, in the past, because parity is not manifestly conserved in the Weyl formalism, it has always been rejected (*15*). With the recent discoveries such an objection becomes completely invalid (*16*).

To appreciate the simplicity of this two-component theory in the present situation, it is best if we assume further the existence of a conservation law for leptons (*17*). This law is in close analogy with the corresponding conservation law for the heavy particles. We assign to each lepton a leptonic number l equal to +1 or −1 and to any other particle the leptonic number zero. The leptonic number for a lepton must be the negative of that for its antiparticle. The law of conservation of leptons then states that, "in all physical processes the algebraic sum of leptonic numbers must be conserved."

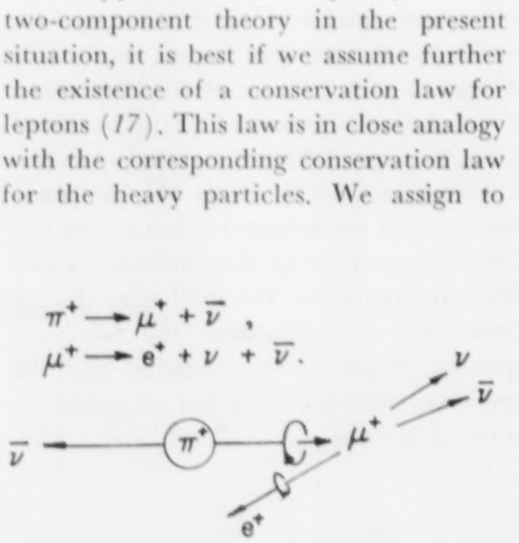

$\pi^+ \rightarrow \mu^+ + \bar{\nu}$,
$\mu^+ \rightarrow e^+ + \nu + \bar{\nu}$.
ν
ν̄
ν̄
π⁺
μ⁺
e⁺

Fig. 5. π-μ-*e* Decay.

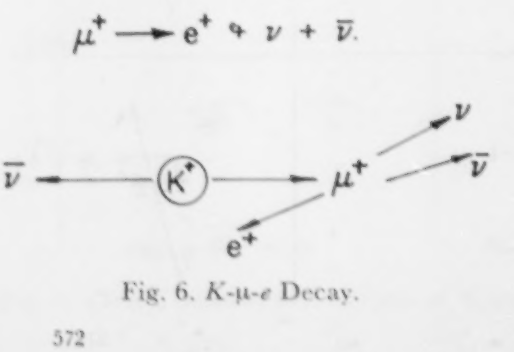

$k^+ \rightarrow \mu^+ + \bar{\nu}$,
$\mu^+ \rightarrow e^+ + \nu + \bar{\nu}$.
ν
ν̄
ν̄
K⁺
μ⁺
e⁺

Fig. 6. *K*-μ-*e* Decay.

Some simple consequences follow immediately if we assume that this law is valid and that the neutrino is described by the two-component theory.

1) The mass of the neutrino and the antineutrino must be zero. This is true for the physical mass even with the inclusion of all interactions. To see this let us consider a neutrino moving with a finite momentum. From the two-component theory the spin of this neutrino must be parallel to its momentum. Suppose now it has a nonvanishing physical mass. Then, we can always send an observer traveling along the same direction as the neutrino but with a velocity faster than that of the neutrino. From this observer's point of view this "neutrino" now becomes a particle with the spin along its original direction but the direction of momentum reversed—that is, it becomes an "antineutrino." However, since the leptonic number for the neutrino is different from that of the antineutrino, these two particles cannot be transformed into each other by a Lorentz transformation. Consequently, the physical mass of a neutrino must be zero.

2) The theory is not invariant under the parity operator P which by definition inverts all spatial coordinates but does not change a particle into its antiparticle state. Under such an operation one inverts the momentum of a particle but not its spin direction. Since in this theory these two are always parallel for a neutrino, the parity operator P, when it is applied to a neutrino state, leads the neutrino to a nonexisting state. Consequently, the theory is not invariant under the parity operation.

3) Similarly, one can show that the theory is not invariant under the charge conjugation operation which changes a particle into its antiparticle but not its spin direction or its momentum.

To test the complete validity of the conservation law of leptons and the two-component theory, we have to investigate in detail all the neutrino processes. For example, in β-decay we must have either

$$n \rightarrow p + e^- + \nu \qquad (\mathcal{H}_\nu = +1),$$

or

$$n \rightarrow p + e^- + \bar{\nu} \qquad (\mathcal{H}_{\bar{\nu}} = -1).$$

This can be determined by measuring the spin and the momentum of the neutral lepton—to see whether it is a neutrino (right-handed helicity) or an antineutrino (left-handed helicity). Through the law of conservation of angular momentum, measurements on polarizations and angular distributions of the nucleus and the electrons can lead to determination of the spin states of the neutrino. Similarly, through recoil momentum measurements, we can find out information about the linear momentum of the neutrino. In the same way we can use not only β-decay but π-decay, μ-decay and K-decay to test the validity of either the two-component theory or the law of conservation of leptons. At present, these measurements have not yet reached a definitive stage (*18*). Much of our future theory may depend on the results of these experiments.

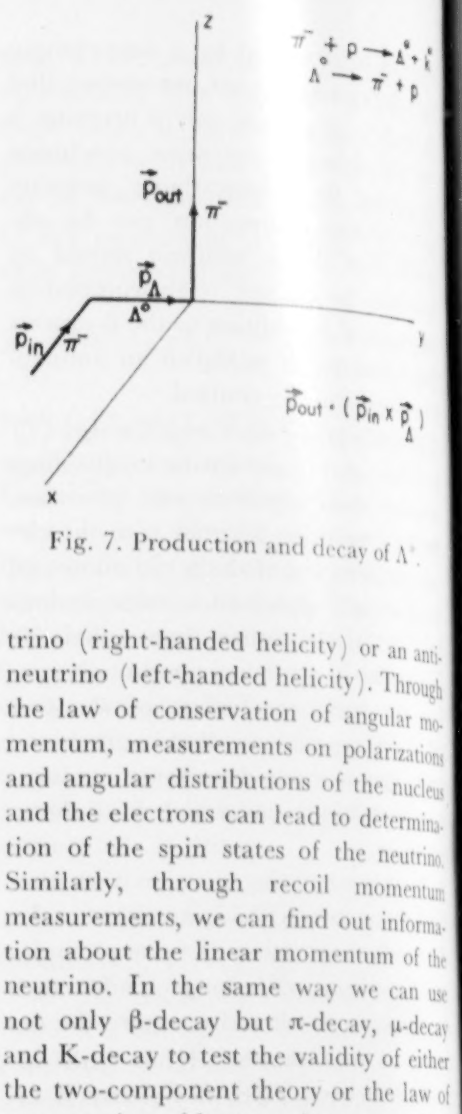

z
$\pi^- + p \rightarrow \Lambda^\circ + K^\circ$
$\Lambda^\circ \rightarrow \pi^- + p$
$\vec{p}_{out}$
π⁻
$\vec{p}_\Lambda$
Λ°
$\vec{p}_{in}$ π⁻
y
$\vec{p}_{out} \cdot (\vec{p}_{in} \times \vec{p}_\Lambda)$
x

Fig. 7. Production and decay of Λ°.

Remarks

The progress of science has always been the result of a close interplay between our concepts of the universe and our observations of nature. The former can only evolve out of the latter, and yet the latter is also conditioned greatly by the former. Thus, in our exploration of nature, the interplay between our concepts and our observations may sometimes lead to totally unexpected aspects among already familiar phenomena. As in the present case, these hidden properties are usually revealed only through a fundamental change in our basic con-

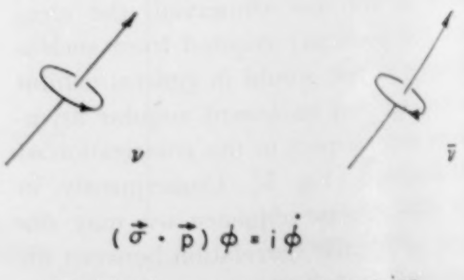


Fig. 8. Two-component neutrino.

cept concerning the principles that underlie natural phenomena. While all this is well known, it is nevertheless an extremely rich and memorable experience to be able to watch at a close distance in a single instance the mutual influence and the subsequent growth of these two factors—the concept and the observation. It is, indeed, a privilege that I have this opportunity to tell you part of this experience in the recent developments concerning the nonconservation of parity and the weak interactions.

References and Notes

1. C. N. Yang, Nobel lecture, this issue.
2. C. L. Cowan, Jr., F. Reines, F. B. Harrison, H. W. Kruse, A. D. McGuire, *Science* 124, 103 (1956).
3. C. S. Wu, E. Ambler, R. W. Hayward, D. D. Hoppes, R. P. Hudson, *Phys. Rev.* 105, 1413 (1957).
4. T. D. Lee, R. Oehme, C. N. Yang, *ibid.* 106, 340 (1957); B. L. Ioffe, L. B. Okun', A. P. Rudik, *J. Exptl. Theoret. Phys. U.S.S.R.* 32, 396 (1957).
5. If the neutrino is described by a two-component theory (see section on the two-component theory) then the result of the large angular asymmetry in Co^{60} decay establishes in a trivial way the noninvariance property of β-decay under the charge conjugation operation. However, this noninvariance property can also be proved under a much wider framework. In this section we take as an example the case of a four-component theory of the neutrino to illustrate such a proof.
6. For notations and definitions of γ matrices see, for example, W. Pauli, *Handbuch der Physik* (Springer, Berlin, 1933), vol. 24.
7. For a summary of these experiments see, for example, *Proceedings of the Seventh Annual Rochester Conference* (Interscience, New York, 1957).
8. R. L. Garwin, L. M. Lederman, M. Weinrich, *Phys. Rev.* 105, 1415 (1957); J. I. Friedman and V. L. Telegdi, *ibid.* 105, 1681 (1957).
9 G. Culligan, S. G. F. Frank, J. R. Holt, J. C. Kluyver, T. Massam, *Nature* 180, 751 (1957).
10. C. A. Coombes, B. Cork, W. Galbraith, G. R. Lambertson, W. A. Wenzel, *Phys. Rev.* 108, 1348 (1957).
11. Crawford *et al.*, *ibid.* 108, 1102 (1957); F. Eisler *et al.*, *ibid.*, 108, 1353 (1957); R. Adair and L. Leipuner, *ibid.*, in press.
12. T. Coffin, R. L. Garwin, L. M. Lederman, S. Penman, A. M. Sachs, *ibid.* 107, 1108 (1957).
13. T. D. Lee and C. N. Yang, *ibid.*, in press.
14. H. Weyl, *Z. Physik* 56, 330 (1929).
15. See W. Pauli, *Handbuch der Physik* (Springer, Berlin, 1933), vol. 24, pp. 226–227.
16. The possible use of a two-component theory for expressing the nonconservation property of parity in neutrino processes was independently proposed and discussed by T. D. Lee and C. N. Yang [*Phys. Rev.* 105, 1671 (1957)], A. Salam [*Nuovo Cimento* 5, 299 (1957)], and L. Landau [*Nuclear Phys.* 3, 127 (1957)].
17. The possible existence of a conservation law for leptons was discussed before the discovery of nonconservation of parity. See for example E. Konopinski and H. M. Mahmond, *Phys. Rev.* 92, 1045 (1953).
18. *Note added in proof*: Recent experiments by M. Goldhaber, L. Grodzins, and A. W. Sunyar (*Phys. Rev.*, in press) showed that in a β^- decay the neutrino emitted is of right-handed helicity.

Science, Industry, and the Abuse of Rights of Way

Frank E. Egler

The problem of improving the present unsatisfactory methods of controlling brush and other vegetation on our national rights-of-way is a fine illustration of the more general problem of getting industry to accept and act upon established scientific principles. The right-of-way domains are those narrow threads of land which serve for transportation and communication of men and materials. They include highways, railroads, electric power and telephone lines, and pipelines for gas, oil, and coal. The rights-of-way of the utility corporations alone comprise an acreage greater than all six New England states combined.

The fundamental scientist traditionally has observed, recorded, and interpreted the facts of the world about him and in doing so has usually remained aloof from society. He has been unconcerned about the discoveries of his science and indifferent about whether they are used for good or evil. In recent years, however, these discoveries have been of enormous import. More and more do we hear of a "Scientific Revolution" that may prove more challenging to the development of the human race than the Industrial Revolution from which we are just emerging. There are three significant recent events which, though differing greatly in magnitude, emphasize the contemporary trend of science toward integrating itself into society.

The first of these events was seen during the last political campaign for the Presidency of the United States. For the first time in our history, a scientific issue became a major feature. I refer to the problems of radiation hazard and of continuing H-bomb tests. Unfortunately the issue became a political football and then was left in the field, deflated. The second event occurred at the annual meetings of the American Association for the Advancement of Science. This august and distinguished body, representing organized science in America, broke with its traditional aloofness relative to the social effects of scientific discoveries. For the previous year, an Interim Committee under the chairmanship of Ward Pigman had been studying the subject, and the report has been distributed as evidence of the committee's interests and activities. The AAAS Council has voted to continue the existence of this committee. In a measure, therefore, science has begun to show a sense of responsibility to provide professional guidance on how to manage and control the revolutionary potentials that it is creating. The third event directly involves our present discussion. For the first time in the 10-year history of commercial herbicidal brush control, a utility corporation presented a system-wide policy that drew upon the common pool of biologic data. At the meetings of the Northeast Section of the Wildlife Society, a leading New England power corporation offered a paper which—in its statements—was scientifically sound. Furthermore, the opinions are in accord with a joint policy statement released at the same time by the Connecticut State Board of Fisheries and Game and the Connecticut Botanical Society.

Following a general review of the problem, I shall consider four of its aspects. The first is a definition of terms. The second is the question of "brush control—for whose benefit?" The third involves the authority of the scientific statements here made. The fourth and last is a short survey of specific factors that have become critical in the actual programming of brush control.

The author is a consulting vegetationist in Norfolk, Conn. This article is based on an invited paper presented at a panel discussion on "Programming Brush Control on Utility Rightofways," Northeastern Weed Control Conference, 11 Jan. 1957.

Review of the Problem

I believe there will be agreement when I state that any brush-control program must aim for "the lowest costs for the most years." I would like to add to that slogan "with the highest good to society," although I realize that there are many who are, by nature, indifferent to this facet of our American economy or of that of the One World which may yield peace. Programming must essentially be a three-cornered cooperative venture, even though triangles are known to be sources of trouble. This particular venture involves a utility engineer, a biologist, and a brush-control contractor.

The utility engineer and the needs of the utility come first and foremost. The needs are simply stated. For electric power, the right-of-way must be adequate, free, and open for patrol, for maintenance, and for repairs. From the standpoint of vegetation, these needs mean permanently low vegetation below the wires, and no trees at the sides that will grow into, or fall into, the wires. Flammability of vegetation, such as grassland, is often an additional factor.

The biologist, with a knowledge of plant species and of plant-communities, is the one to indicate which plants it is desirable to save in a discriminate brush-control program. He can predict the post-treatment vegetation, how many years it will last, or how rapidly it may be invaded by undesirable trees. It is the biologist who has been missing, ignored, or ridiculed at the council tables of the programmers. I use the word *biologist* guardedly, for there is much confusion about the term and the field. If the biologist is consulted at all, the engineer is likely to choose him and to expect him to be—as we used to consider the family physician—a jack of all related trades.

Some companies have employed biologists. All too often, however, they have chosen foresters, agriculturists, agronomists, biochemists, or plant physiologists—men who may be competent in their own fields but who, in making recommendations on this subject, are under the same handicap that a surgeon would be under if he were asked, and forced, to treat an emotional disturbance. In other instances, a competent biologist is "neutralized" by an engineer of higher echelon. More often, no biologist is consulted. For example, one of the world's largest corporations (which, in one division alone, spent \$3.5 million spraying 200,000 acres in eight years and is still spraying) does not have a single botanically trained individual to judge the effects of its nation-wide spraying program. Although this corporation spends millions of dollars a year on research through a laboratory of deserved renown, not one dollar goes to the study of the effects of chemicals on the plant-communities. What little research is done is concerned only with specifications for the herbicides themselves.

In a second instance, another mammoth corporation in the chemical manufacturing field finally appointed one of its entomologists to carry through a costly and time-consuming investigation of vegetation management on rights-of-way. By good fortune, they chose a remarkably fine individual, with an unusual hobby-interest in botany. I have a letter from the company indicating essential approval of all aspects of that program (with which I was then affiliated). His final report was nearing completion when an unexpected heart attack took his life. To my knowledge, the investigation was shelved, and I am not aware that there has been any significant change in the policy of the company. It took courage to do what this man was doing.

The third and last of this irregular triangle is the line-clearance contractor. It is he who knows the various mechanical and chemical techniques for brush control and who can estimate the relative costs of the different approaches in the light of the biologist's and engineer's recommendations and needs.

Outside of the triangle, but often manipulating thought within it with consummate dexterity, is the chemical manufacturer. Chemical herbicides are assuming an ever-increasing role in commercial brush control, and they deserve to. The chemicals used are generally derivatives of 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid, commonly known as 2,4-D and 2,4,5-T. Ammonium sulfamate is also used. It must be understood that these chemicals have no known adverse effects on any animals. If used unwisely, they do have an extremely detrimental effect on wildlife habitat, and this, in its way, is far more disastrous than any killing of the animals themselves. An animal reproduces readily; habitat does not.

In the use of these herbicides, many practices are followed. Much of the so-called controversy revolves around two common and antithetical procedures. One is indiscriminate, blanket, summer-foliage spraying with power equipment. The other is discriminate basal-bark spraying at various seasons, usually with small or hand-powered equipment. For the first procedure, water-borne sprays of low concentration are used; for the latter, oil-borne sprays of high concentration. Much of the discussion that follows is based on the different biological and economic effects of these two techniques, although it must not be assumed that either, or any, technique can be adopted to the exclusion of all others.

"Brush Control"—the Term

It is my sober opinion that the rational management of vegetation on the rights-of-way of this nation will never be established on a sound basis as long as the problem is referred to as "brush control." Both words in the term are heavily laden with factual error and with insidious emotional connotations.

The word *brush* for example—"brush" refers to any woody vegetation, including trees and all shrubs, even those under one foot in height. To many engineers—and I speak from my experience with them—there are but two kinds of plants, brush and grass. Brush grows up into trees; engineers do not want it. Grass stays low; they want it. *Brush* has actually become a dirty word, and advertising campaigns have been very effective in promoting the idea that no brush can be tolerated on a right-of-way. When sales and marketing divisions bring modern motivational psychology to bear on this thought, the result is very impressive. Therefore, the accepted scientific fact that many types of brush—that is, the low shrubs—not only can be advantageously saved but may be extremely valuable with respect to the future control of trees is a statement contrary to common belief in the industry. The maenads of Madison Avenue have prevailed over the soberness of science.

The word *control* involves even worse problems, for it has been used so much that electrical engineers have become satisfied with repeated control and do not recognize that "elimination" is often a scientific possibility, especially where tree roots are involved and where invading seedlings do not occur. On the other hand, we should be realistic and recognize certain psychologic facts. Those who are in the business of "controlling" are rarely interested in "eliminating." This is true in industry as well as in philanthropic and scientific activities. I am sure that some social workers would be deeply grieved if underprivileged and problem families suddenly ceased to exist. I recall also a discussion I once had with a pathologist, whom I was trying to impress not with the importance of controlling a forest disease but with the possibility of furthering an already natural trend toward developing a resistant strain of the tree species. The hour was late, and other factors contributed to an unusual element of frankness in his words. "But Frank," he finally confided, "don't ask me to eliminate the disease. I like diseases. It is my job and my profession. All that I want to do is to control them." And so it is with many in this industry. I accept the fact that they may just want to "control" brush. But when science can eliminate undesired brush and thereby effect an economy for society as a whole, the scientist will say so.

Brush Control—for Whose Benefit?

Brush control is a business, a profession, an art, and a science. Any reasonable discussion of programming brush control should recognize the fact that different people are interested in it for different reasons. What I must now say may offend some readers. However, these are not personal opinions but are based on factual experiences and expressed with the impartiality of a sociologist. I seek neither to convince some of you nor to alter the unalterable but to generalize from the variety of contacts in my own background.

For our purposes, the people interested in brush control can be segregated into four groups. The first group includes the chemical manufacturers and the spray and line-clearance contractors. In this case, I do not see why we should not all face the fact that more brush means more business for these organizations, and thus that any science-based program recommending the elimination of brush will not be welcomed. For example, at a conference in the summer of 1952 it was reported that an owner of a local and successful spray business, after hearing a talk on long-term, lost-cost vegetation management, commented to another group in the evening that "all this talk about stable low brush cover may be good enough. But I have a son coming up in years, and when I retire I want enough new brush around so there will be business for him. What better way than to spray, so that the trees will come back in again."

It is my opinion that this philosophy, though rarely so bluntly and honestly admitted, is nevertheless widespread. I have, for example, no evidence that any chemical manufacturer has incorporated scientific data concerning the relative stabilities of different types of post-spraying vegetation in their sales and marketing literature. Almost all line-clearance contractors have studiously avoided the subject also, although I know of two that are outstanding exceptions. They act on the philosophy that, although there may be less brush per acre in the future, there are many brush-covered acres. These are small organizations, however. That they are not among the largest is possibly an indication of the disadvantage of espousing a minority viewpoint, even if it is scientifically correct. Furthermore, there are problems inherent in selling a new approach. When sales representatives have long been in the habit of taking orders for what a consumer has been conditioned by others to demand, even if it is morphine, they are unwilling to sell, and incapable of selling, an idea, and thus, through poor salesmanship, can undermine their own corporation.

The second group involves the utility corporations themselves. The rights-of-way of these corporations include railroads, pipelines, electric power lines, telephone lines, and roadsides; my personal experience has been mainly in the field of the electric utilities. Among the utilities we must accept the fact that within any one company there can be remarkably diverse reactions to the different aspects of brush control. The engineering departments are directly concerned with the construction, maintenance, and repair of the rights-of-way and the lines upon them. Very often these departments find themselves already committed to programs that disregard certain scientific knowledge. I say without rancor, and with complete sympathy and understanding of their individual problems, that such departments, when confronted with certain scientific evidence, are primarily concerned with saving department funds, department jobs, department face, and individual faces. Of these, the last leads all the rest. Five large power corporations strikingly exemplify this situation—a reality which we must all accept.

Public relations departments, on the other hand, have an extremely different approach to the subject. They are highly sensitive to public opinion and are often in a far freer position to evaluate the voice of science. Indeed, this sensitivity can be a disadvantage. I myself find that I can present, coldly and with dignity, the facts of accumulated scientific literature and the results of a decade of field research without accomplishing as much as can one irate conservation-committee chairman of a local garden club, who tosses off a perfumed letter that all but singes itself. Furthermore, whether or not the lady in question is scientifically correct may be irrelevant to the state of her temperature and to her effectiveness. Scientists should recognize the value, and the danger, of such thermal bombs.

And finally, in addition to engineering and public relations departments, there is top management. We must recognize that top management may be open to suggestions and to developing views of its own. Although generally it does not wish to be bothered with activities that traditionally have been handed down to departments, time and time again I have found only in top management (and not always here) a respect for science and a concern for company economies. Within the three aspects of this second group, in particular, I see little prospect for permanent relief unless we can establish a higher standard of scientific literacy than now exists. By "scientific literacy" I do not mean a knowledge of technical details equivalent to that of the professional expert. I do mean an awareness of the complexities sufficient to distinguish the voice of authority from that of fraud and quackery. The urgent need for such literacy was obvious during the course of the panel discussion for which this paper was originally prepared.

In the third group, which may or may not benefit from brush control, is the forgotten person in this entire program. It is doubtful whether he was represented in the audience at the time the panel discussion took place. I refer to the man who is the owner of this land in a free democracy, to the man who has all rights and prerogatives on these 50 million acres except as they concern the transmission and distribution of the commodity involved. I doubt whether any utility corporation involved in brush control has presented an impartial and factual account of the varied and multiple methods of accomplishing such control, all economically feasible but differing greatly in owner benefits. (In personal discussion, at the original conference, one utility representative admitted frankly that his company deliberately tried to keep owners uninformed about different spraying techniques. If there was any questioning, the company had a policy of sweeping away opposition with claims that theirs was the "only proven way"—a policy which he thought excusable even if not correct. Another company representative seemed to agree that the owner was the forgotten factor and implied that he should stay forgotten, for, "after all, what the owner wants, we do—regardless!")

Here is a striking instance of the power of an owner in my own state. A woman happened to be at home when blanketeering operations started on her property. Single-handedly, with no scientific knowledge but with a large measure of common sense, an effusion of Latin blood, and the vigor of a chick-defending mother hen, she cowed a large force of laborers. The result, today, is the finest single example on the lines of this company of vegetation that is best for the company and best for society. It is in striking contrast to the rest of the blanketeered right-of-way in the town—a town whose active sportsmen's association was ineffective in dealing with the company. This corporation has persistently destroyed more wildlife habitat than the state game department has produced in its entire history, despite the fact that scientific information has been repeatedly brought to its attention by many groups since 1947.

Fourth and last comes the "general public." By this I mean neither the owners nor the land management, but "society," which has an indirect stake in these lands. I refer to the forestry profession, which may be involved with alternating hosts of forest diseases. Members of the wildlife profession and sportsmen have a large interest, for the vegetation can serve as habitat, as food, and as cover for game populations which will breed here and then spread to other lands. Berry pickers, hikers, bird watchers, and other recreationists often utilize these rights-of-way. Then there are the naturalists and scientists, who often find on these lands rare and unusual plants and animals and biotic communities. In some ways the general public has one of the largest stakes, but it does not know about it. One reason for this lack of knowledge on the part of the masses is that this subject has been neglected or openly avoided by almost all federal and state agencies. Such agencies are traditionally concerned with the conservation of timber, forage, wildlife, crops, soil, and water, on public and wholly private lands. For reasons that are understandable, however, if not entirely excusable, the natural resources in a very sizable area of our nation have been left defenseless against overzealous commercial exploitation.

Programming—Whose Scientific Opinions?

To the best of my knowledge, the items I will be mentioning in the fourth part of this article are not personal opinions, are not matters of controversy among scientists in this field, and may be considered reasonable scientific generalizations in the light of existing data (*1*). I am not aware of any contrary generalizations emanating from those scientists who are now involved in related research or practice.

At the present time there are three national organizations that have committed themselves to an interest in these 50 million acres. The Wildlife Management Institute has commissioned a booklet on the subject, has sponsored a questionnaire that has been sent to almost 1000 electric utility corporations, and is aiding one of the largest corporations in launching a "rightofway vegetation management" program. The Boy Scouts of America National Council has a project in their Del-Mar-Va camp, for purposes of Scout education. The Garden Club of America, national Conservation Committee, was instrumental in furthering a project in central New York which, in turn, would aid member clubs in handling local problems. Furthermore, the federal Fish and Wildlife Service has stated its official policy, by request of the editor of *Public Works* magazine. This policy appeared in the issue for April 1955.

Two state conservation departments have issued definitive policies: the Connecticut State Board of Fisheries and Game and the Pennsylvania Department of Forests and Waters. One state scientific society, the Connecticut Botanical Society, has an active Rightofway Vegetation Committee. This committee is associated with certain representative projects in its territory, including those of an Audubon Society chapter, a college arboretum, a sportsmen's club, a foundation, a land owner, and a corporate sanctuary. Essentially the same ideas are expressed in a U.S. Forest Service foreman's manual for roadside spraying in Region Seven. The national Committee for Brush Control Recommendations for Rightofways is associated with approximately 20 projects, extending from Florida to northern New England. There is no basic difference in the scientific or economic approach of these projects or groups. I am sure there are many other organizations that should be included here, but I have no published evidence of their policies.

Brush-Control Programming

In the following and final paragraphs, specific factors will be discussed which, as the biologist's contribution to a sound vegetation management program, have been found to be of critical importance. These will be discussed in five categories,

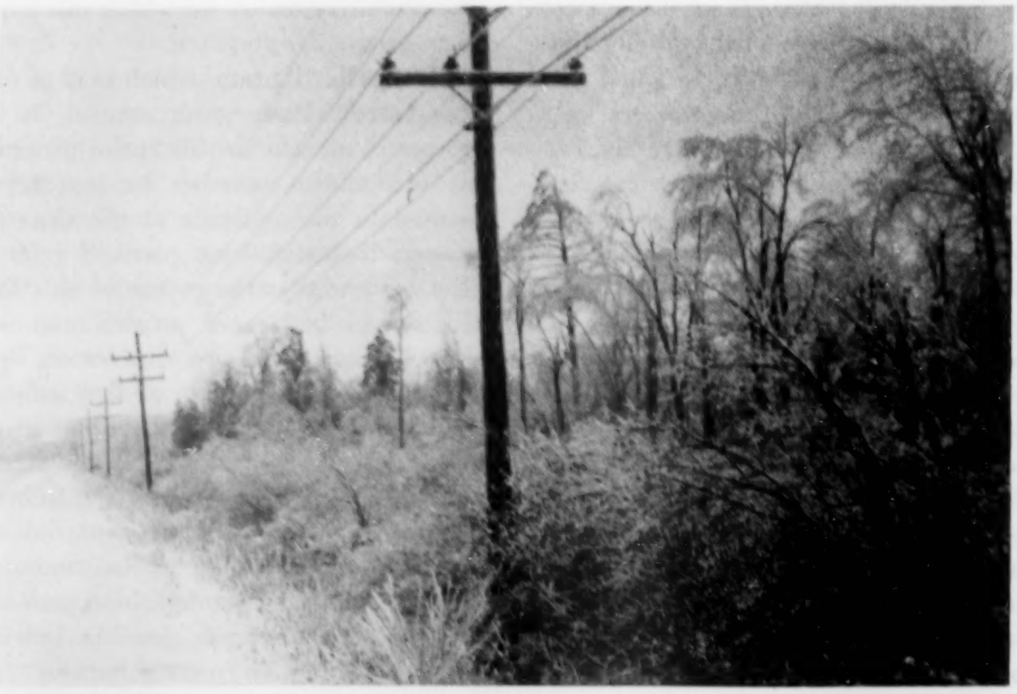


Fig. 1. Stable roadside thicket, mainly of low willows, adjacent to White Memorial Foundation, Litchfield, Conn. This entire vegetation has subsequently been blanket-sprayed. [Photograph by Gordon Loery]

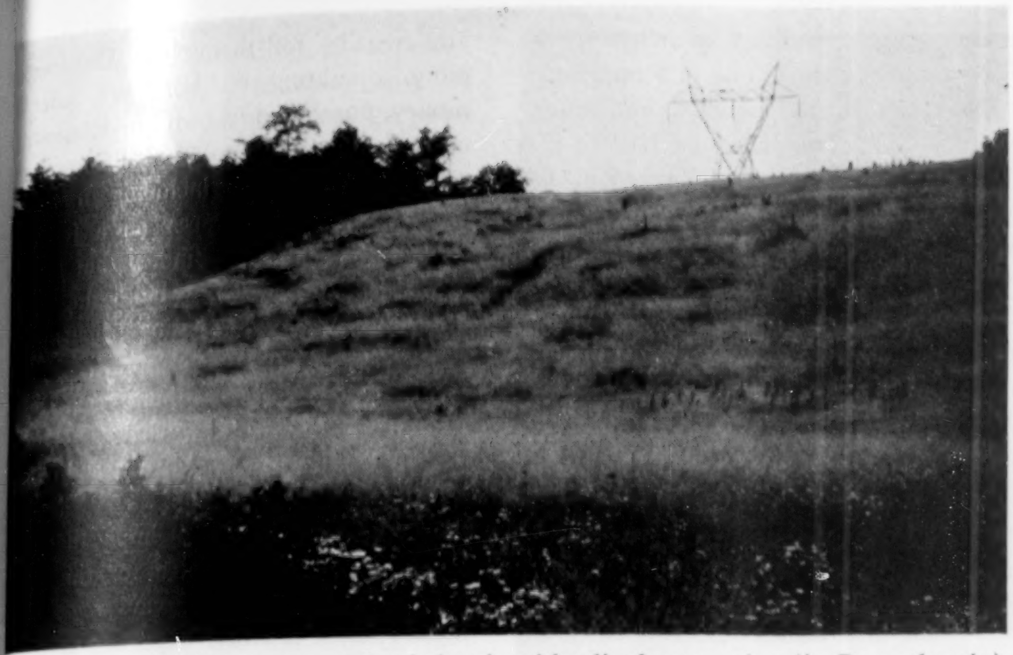


Fig 2. A type of right-of-way grassland that is misleadingly attractive (in Pennsylvania). It is a thin vegetation of poverty grass—a relative desert for wildlife—and will be costly to maintain because of invading pines.

pertaining respectively to applied phytosociology, herbicides and plant-kill, commercial brush control, conservation interests, and the general idea of research and development.

Applied Phytosociology

If any biological generalizations are to be made, the leading idea is that, in most mixtures of shrubs and trees, the trees are of the same age as, or older than, the associated shrubs. Tree seedlings are relatively unusual among most shrub covers. There are exceptions, especially in the tropics, and these must be carefully evaluated. Root systems are frequently much older than aboveground parts, and this fact plays an important part in low-cost management.

Another generalization concerns the relative stability of upland grasslands and shrub covers. In most cases shrub communities retard reforestation more successfully than do grasslands. Rhododendron, laurel, and hazel are notorious in this role (Fig. 1). Pines are eminently successful in invading grasslands; so are ashes, elms, maples, and birches (Fig. 2). Sound vegetation management involves the encouragement of that plant-community which is most stable through the years. A community that goes to forest twice as quickly as another does is twice as expensive to maintain, and some communities (including some produced by blanket-spraying) advance 20 times as quickly as others.

Sound brush control should start with initial clearing of the line. Too often there is unnecessary destruction of valuable cover at this time, cover which would mean future savings (Fig. 3). Much of such destruction is accompanied by soil-baring, which the forester often purposely effects in order to increase reforestation.

"Construction" of a suitable seminatural vegetation should be clearly differentiated from "maintenance" of that vegetation once it is attained. These two costs should receive the same consideration as comparable construction and maintenance costs of poles and towers. The situation is analogous to that of separating the construction cost of your home from its continuing maintenance costs.

Vegetation is highly variable, from town to town, county to county, and state to state. As in the case of other vegetation management procedures, such as forestry or range pasture and wildlife management, a knowledge of existing local variations is essential, and economically sound, as a prerequisite to a rational program.

The botanical aspects of the program can be planned in terms of the length of the life of the line itself, be that 25, 50, or 75 years. There is adequate botanical literature on the stabilities of vegetation types, some of which involve communities that have perpetuated themselves for several centuries. This aspect of the problem seems to be particularly mystifying to engineers, one of whom arrogantly refuted during the course of the panel discussion on "Programming Brush Control on Utility Rightofways" all such knowledge, even when it involves stability of only a few years' duration.

Herbicides and Plant-Kill

Past chemical treatments must be clearly evaluated in several different respects. The easiest to observe is "top-kill" or kill-to-ground. I estimate that 95 percent of the companies of this nation are judging their brush control in these terms. As "kill," it is comparable to mowing the lawn, which is not done to kill the grass. Less easy to observe is root-kill, which cannot be adequately judged until at least two years after treatment. I know of only half a dozen companies who are properly judging root-kill. The economic importance of this distinction should be quite obvious, for root-kill techniques may cost up to twice as much as one "chemical mowing," and yet some companies are top-killing for the fifth go-around. The third item in evaluation is a consideration of the vegetation that remains after treatment. I know of no company that has any policy on this aspect of vegetation management. The fourth and last item involves reinvasion of the postcontrol vegetation by new tree seedlings. Here also I know of no company which is employing the technical know-how to estimate this all-important economic factor. Although they may mention certain new brush as being composed of reinvading seedlings, the species they mention (most frequently aspen) indicates the error of their judgment. I estimate that over 90 percent of commercial brush control is judged purely in terms of these four factors, based on engineers' estimates of the numbers of above-ground stems.

Commercial Brush Control

Indiscriminate blanket-spraying leaves a bright brown swath in midsummer that has often evoked adverse criticism from the public. In itself, this situation cannot be considered undesirable, provided this is the cheapest technique for achieving the highest general values. On the other hand, I have not yet seen the brown-out, except for local stretches of several spans, which I would recommend. Furthermore, evidence is abundant that such blanketeering techniques more readily kill the low, desirable shrubs (which do not return by reseeding) and tend not to kill the undesirable tree roots (Fig. 4).

One of the most unfortunate theories, and one that has regrettably gained widespread acceptance because of a superficial rationality, is that of the desirability of an initial blanket-spraying followed by later years of selective spraying of what is left. To the average engineer, the vegetation in the summer is a jumbled and confused mass of verdure. He cannot distinguish shrubs from trees. With a vigor that approaches a neurotic compulsion, he wants "to get rid of all that brush." After that, he promises to selectively spray out the trees. More often than not, observations in the dormant season would indicate that there are far more desirable shrubs than intermixed trees. Very frequently I have seen long stretches blanketed with spray when there was but a handful of young trees—trees that could have been cheaply root-killed by hand equipment. Furthermore, these initial foliage sprayings, wholly unwarranted on biologic grounds, frequently have very little root-kill effect on the tree component. In the subsequent selective spraying for eliminating the surviving trees, the cost may be just as high as if this were done in the first place, while conservation values have been permanently lost.

Of all the right-of-way spraying I have observed in recent years, I would judge that more than 50 percent has been done from 1 to 20 years too soon. Furthermore, there is empirical evidence indicating that taller unwanted brush is often more easily root-killed than is younger brush. In addition, each year postponed means lower average costs. On the other hand, I recognize the economic forces that favor early spraying. Any contractor is constantly pressuring the utilities for these premature jobs, knowing full well that if he does not get the contract, his competitor will. There is no force, even within his own company, to aid the utility engineer to withstand this pressure.

In judging these sprayed rights-of-way of the nation, I would estimate that over 75 percent of them have already had a definite loss of vegetation "capital" because of indiscriminate blanket spraying. The act is comparable in many ways to throwing the baby out with the bath water. This loss will continue, until the validity of biologic knowledge is recognized.

A rational program of vegetation management is definitely a multitechnique procedure. It involves a combination of mechanical and spraying techniques, depending on the local and predominating vegetation conditions. I realize that my name has been linked with one particular technique, largely because I was associated with some of the original research on that technique a decade ago. I accept the fact that, among engineers, there is an overpowering tendency to tie one to a technique rather than to a biological end-result. The technique they can understand; the end-result can be accepted only in relation to that scientific literacy previously mentioned. In my own experience, I no sooner squirm out of one technique tie-in than I am pulled into another. I cannot emphasize too strongly that, in the last analysis, the vegetation, not the engineer, should determine the technique.

Another unjust and unwarranted claim is that selective power spraying is a far more efficient procedure than knapsack spraying (where a biologist recommends knapsack spraying) and that it can pinpoint out the undesired trees without undue harm to the surrounding shrubs. One electric utility corporation in particular has tried to placate the wildlife interests by extolling this claim. Whether or not such selective power spraying is generally feasible is yet to be proved. In the case of this company, it was found that patches of shrubs 30 feet in diameter would be ruined in the course of spraying a single small tree. It is doubtful, anyway, whether such trees were root-killed by such treatment, and, even if they were, they would not have been critical to the maintenance of the line for many many years to come. Surely common sense, rather than scientific knowledge, is needed in such instances as these.

Bulldozing and discing, except in certain very limited instances, are not indicated as suitable techniques for long-term vegetation management. Such procedures are widely known to encourage reforestation, and those few companies that have prematurely endorsed them will eventually realize the problems they are creating for themselves. One company, operating on borrowed federal money, purchased its own bulldozers and carried to completion a bulldozing operation on 5000 acres, including an excellent demonstration area on a federal experimental forest. Finding that brush is returning after this bulldozing, the company is now purchasing a helicopter for a program of aerial spraying. This decision was made without regard for existing biologic knowledge, which strongly indicates the inadvisability of such a procedure.

It is not my intent to imply that the needed biological advice for the programming of right-of-way vegetation management is either expensive or difficult to obtain. Suitable specialists exist in a dozen American universities, and there are several national organizations, and their branches, that would cooperate. It is my opinion that adequate recommendations, based on field surveys, could be prepared at the absurdly low cost of 25 cents per acre per year, plus expenses, for three years, beyond which time the program would be self-maintaining. In view of the fact that some companies have spent $200 per acre, or more, within two years, and on a treatment that involves a capital loss, many people have a right to feel disturbed.

Conservation Interests

At times, the wildlife profession has disregarded its own interests by a too-ready admission that any right-of-way, even of legume-killed poverty grass, is better than closed forest. This is true, but certain industrial interests have jumped the statement, through under-

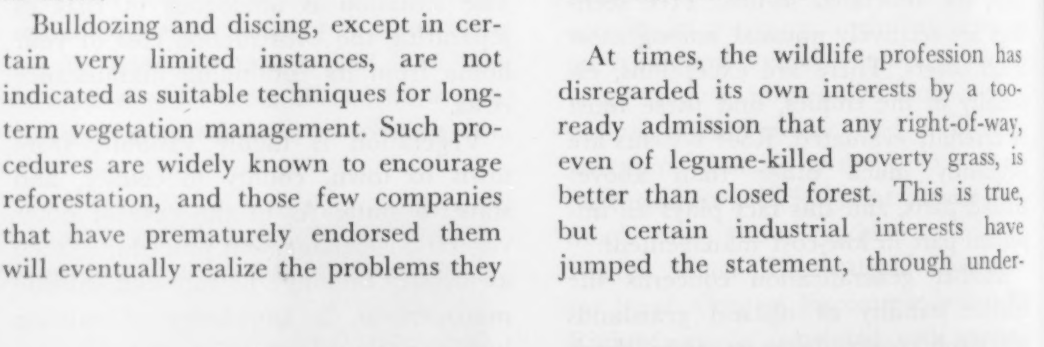


Fig. 3. View of willow thicket (in mid-background), stable for several decades, that has been unnecessarily destroyed (foreground) for right-of-way sides (White Memorial Foundation, Litchfield, Conn.). [Photograph by Gordon Loery]

standable misunderstanding. If no right-of-way produces x animals, and a sprayed-out grassland produces $2x$ animals, one would choose the poverty grass—if those were the only two alternatives. The choice, however, includes a third—mixed edge effects that can produce $10x$ animals. Even if one has been a coal miner, he should not stoop to pick up garnets if diamonds are also present!

Among the multiple-use aspects of these right-of-way lands, that of providing food and cover for game and other forms of wildlife seems to be of greatest importance. During the course of the panel discussion, there was one supercilious claim that the shooting of insulators by trigger-happy hunters makes it impossible for utility corporations to cooperate with sportsmen. I am amassing considerable data that are pertinent. Apparently this destruction is almost always a local problem, traceable to delinquents of various ages. One rural electric cooperative in the Southeast solved the problem effectively and permanently by apologizing to its customers for the disruption of service and asking for their aid in locating the guilty party. (He was quickly found.) Moreover, there is a difference between habitat lands and shooting lands. I know of no professional wildlife manager who demands these lands primarily for shooting. In some instances, however, corporations have knowingly constructed their rights-of-way through state game lands, with foreseeable results.

Research and Development

One further word should be said about the role of recent and future research and development. The terms *research* and *development* have an aura of respectability and dignity that can be unwarranted. Far more often than I would like to admit, the claim for additional activity of this kind is a cloak, somewhat diaphanous, for ignorance, confusion, laziness, unmitigated procrastination, or sheer cowardice. I can document that strong statement, but I trust I am not forced to do so. This is as true in science as it is in industry. Within this discussion, I wish to emphasize very strongly that marked improvement can be made in the existing commercial practices without additional phytosociologic research and development. The need today is for the amalgamation into those practices of the common fund of scientific knowledge—knowledge which can no longer be accredited to any one individual, certainly not to myself. I refer to the literature on the nonforest areas that existed at the time of the white man's arrival and that still exist—areas such as the balds and slicks of the southern Appalachians and the blueberry heaths of West Virginia. I refer also to commonly accepted forestry practices, such as scarification of the soil, and destruction of the hazel brush of the Lake States and of the Appalachian rhododendron thickets in order to favor tree regeneration. It is not additional knowledge of this kind that is needed. The problem is for industry to catch up with what is already known.

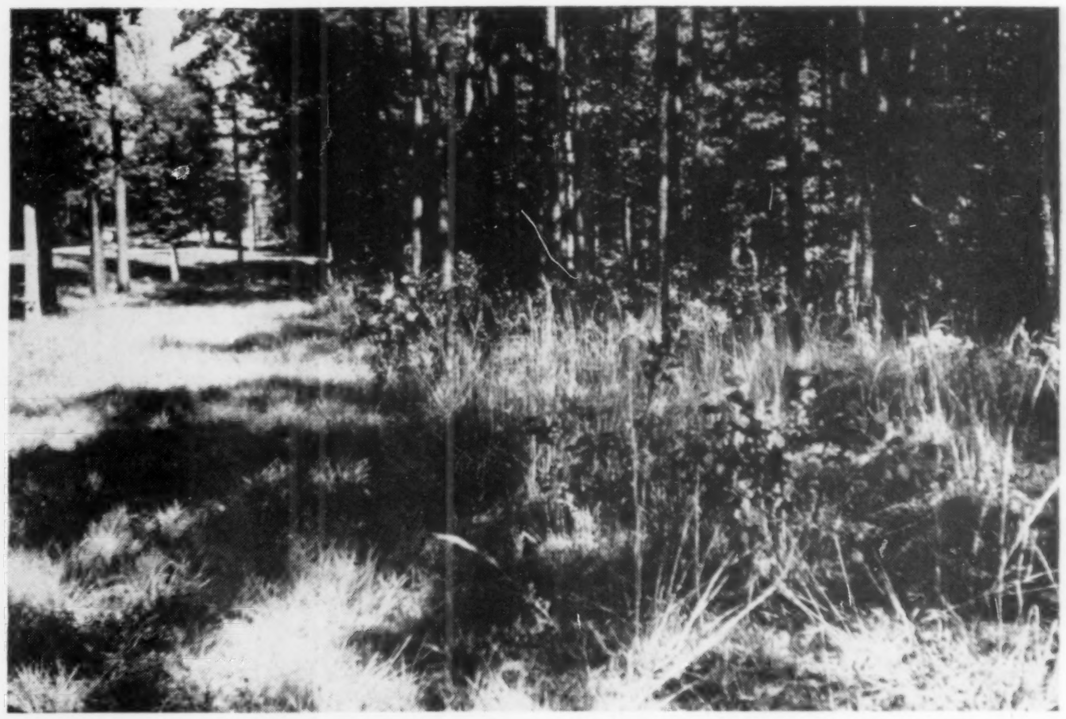


Fig. 4. Spray-induced grassland below a telephone line, open to invasion by pine seedlings (in Virginia). Unmowed roadside grass is a fire hazard. Present spray policy is to reach out under the adjacent forest, killing out desirable food and cover shrubs and leguminous herbs.

And, finally, I wish to say that the cheapest means of achieving brush control for the future is by the encouragement and utilization of *other plants.* Such plants often already exist on the land and can be saved by discriminate programs of brush control. I accept the fact that this biologic means of control is distinctly alien to the thinking of—and therefore largely ignored by—the industrial sponsors of the Northeastern Weed Control Conference.

In conclusion, I wish to apologize if I appear to have unduly criticized certain facets of industry for the failure to utilize scientific knowledge. The fault is definitely two-sided. If science has not claimed respect, it is the fault of science. If science is ridiculed at conferences of this type and not one scientist stands up in defense, those scientists present are at fault. If scientific fact is blatantly overridden, there may be something wrong with the science professors in the engineering colleges. If scientists are invited to adorn industrial conferences and then are discarded when they do not sing the proper song, then scientists should seek some other way to influence the national economy. If industry-sponsored research is prematurely taken from the ivory tower and deliberately distorted for marketing purposes, the scientist who aids and abets this is the one to be blamed.

The integration of scientific fact into our society, for the general good of that society, is not to be accomplished without a broad and general understanding, on the part of all its citizens, of the nature of the different sciences. It is not accomplished without some facets of that society being temporarily and locally dislocated. In this connection I would say that our little problem of achieving scientifically sound right-of-way vegetation management, involving an area greater than all of New England, is one typical facet of the general problem—the problem which dominated recent meetings of the American Association for the Advancement of Science. That problem recognized the urgent need for scientists to abandon their traditional impartiality and to provide professional guidance in the integration of their discoveries into our way of life. I do not, in this instance, have the answer for this segment of industry, but if I have brought some of its traps and hazards to your attention, I shall have accomplished my aim.

Reference

1. Frank E. Egler, "Vegetation Science Concepts: I, Initial Floristic Composition, a Factor in Old-Field Vegetation Development," *Vegetatio* 4, 412 (1954); "Fifty Million More Acres for Hunting?" *Sports Afield* 132, No. 6, 48 (1954); "Vegetation Management for Rightofways and Roadsides," *Smithsonian Institution Rept. for 1953* (1954), pp. 299–322; "Selected list of publications concerning . . . rightofway vegetation management," Committee for Brush Control Recommendations for Rightofways, Release No. 5 (1954, 1957). (Available from the Committee for Brush Control, Box 38, Norfolk, Conn.)

News of Science

Snyder Statement on Education Legislation

Laurence H. Snyder, chairman of the AAAS Board of Directors and retiring president of the Association, recently appeared before the Senate Committee on Labor and Public Welfare, which has been holding hearings on proposed legislation for additional Federal support for education, especially science and language education. For an analysis of the two major bills under consideration, S.3163 and S.3187, see Dael Wolfle's "Science Education Legislation for 1958" on page 389 of the 21 February issue of *Science*. Snyder's statement to the committee follows.

"As a representative of the American Association for the Advancement of Science, I welcome the opportunity to discuss with you some of the problems of improving science and education in the United States. These problems have for long been of concern to this committee. They have long been of concern to my Association also. As two rather widely separated examples, I might cite the fact that the presidential address of one of my predecessors a century ago was one of the first public statements of the need for a National Academy of Sciences, a proclamation that President Lincoln heeded a few years later in establishing the National Academy, and that a decade ago the American Association for the Advancement of Science prepared the material on science education that was included in the report of the President's Scientific Research Board in 1947—the report that is usually known as the Steelman Committee report.

"Three years ago the Association greatly increased its attention to the problems of improving education in science and mathematics. This we did because we agree completely with the authors of both S.3163 and S.3187 that the primary requirement in education today is to improve the quality of education, especially education in science and mathematics. We need more and better school buildings. We need to pay our teachers more adequate salaries. We need to overcome the handicaps that prevent some bright students from attending college. But above all, we need to offer education of higher quality to the students who will be the teachers, the statesmen, the scientists, and the leaders in business and other fields of tomorrow.

"Let me explain why we put such stress on quality. There are two reasons. The first lies within the educational system. During the past three quarters of a century, the population of the United States has increased threefold. During those same years the population of our schools has increased a hundredfold. The nation's teachers have done an excellent and devoted job of meeting this rapidly expanding load. But note what we ask them to do. We want them to take care of practically every child in the land from the age of five or six to the age of sixteen or older. We want them to help the retarded and handicapped child; to serve the needs of the average; and to develop the talents of the gifted. Seventy-five years ago, most of the students who graduated from high school went on to graduate from college. It was appropriate then for the high schools to concentrate on preparing their students for college. Now, under the weight of a majority of students who will not, and in many cases should not, go to college, the high schools can no longer concentrate on college preparation. In the course of these changes, some of the virtues of intellectual rigor, of preparation for more advanced work, and of high quality education for the students of highest ability have been submerged under the burden of other claims on educational facilities and teachers' time. In science and mathematics, the problem has been particularly acute because industry and government have been able to outbid the schools in recruiting college graduates with training in science and mathematics. Consequently, there have been some special difficulties in securing an adequate number of well-trained teachers of science and mathematics, and instruction in those vital subjects has suffered more than in other fields.

"The second reason for our emphasis on the importance of improving the quality of education comes from within science itself. Less than 15 years ago the first atomic bomb was exploded. During these 15 years man has learned of the tremendous potentialities of nuclear energy and has witnessed a number of other dramatic technological developments. Atomic fission and fusion, satellites and space exploration are important in themselves, but in a larger sense they are merely symbols of a scientific revolution that we are entering. We are on the verge of vastly greater power over the forces of nature than we have ever held in the past. The evidence is already dramatically evident: compare the power of atomic fusion with the power of TNT, or the speed and range of Explorer with the speed and range of an airplane. Throughout the sciences discovery is accelerating. Astronomy, astrophysics, geology, and geophysics are greatly expanding our knowledge of the world, and of the universe. Chemistry is creating new marvels. In genetics, in pharmacology, in biochemistry, in neurophysiology, we are conducting experiments that were inconceivable five or ten years ago. We are getting close enough to some of the secrets of living matter so that scientists of all fields understand, and many agree with, Vannevar Bush's statement last month that if he were starting his career now he would be a biologist.

"We may be frightened or gladdened by this scientific revolution and its consequences. But like it or not, we cannot escape; we cannot stop the rush of scientific developments of which I speak.

The discoveries are being made in this country, in England and Europe, in the Soviet Union, and soon we will have to add China and other countries to this list. We cannot hide from this scientific revolution. There is no place to hide.

"The only conceivable thing we can do is to prepare ourselves as intelligently as we can to take full advantage of the rush of future developments. To do this we must maintain our own scientific status with respect to the rest of the world and we must improve the quality of our educational system so that our citizens of tomorrow will be able to contribute to and realize the benefits of this scientific revolution. In this improvement of education, one of the goals is to educate future scientists. But of at least equal importance is to educate our future statesmen, lawyers, business leaders, and men and women of other professions so that they will have a better understanding of science and will be better prepared to deal wisely with the benefits, the problems, and the dangers of rapid scientific advance.

"This point I want to emphasize as objectively and as powerfully as I can. As an indication of the importance we attach to it, the American Association for the Advancement of Science is holding a special conference of leading scientists from all parts of the country and from all fields of science. The background of that conference is the realization on the part of scientists of the urgency of preparing ourselves for the revolutionary developments ahead. The purpose of the conference is to consider the actions we should take now to strengthen science and education in the United States.

"The American Association for the Advancement of Science is a particularly appropriate organization to hold such a meeting because of its central position among the scientific organizations of the country. In our 110 years we have fostered the development of many of the leading scientific societies of the United States, and those societies—as well as others that have been established independently—are our close friends and formal affiliates. The AAAS has, therefore, not only its own individual members, who number about 55,000 men and women from all fields of science, but also has 279 affiliated societies that cover all fields of science. No one pretends to speak for all of the scientists of the country—some of whom are rather complete individualists—but our conference next month will come as close to doing that as an association can.

"I hope that you will forgive me for taking so long to get to the specific provisions of the legislation now before you. I have taken that time for two reasons: to tell you how vitally important it is in the judgment of scientists to improve the quality of education; and to explain the background of our own thinking concerning the several provisions of the bills under consideration."

Consultants. "We consider the provisions for improving teaching and education to be the most important feature of the legislative proposals being considered in these hearings. We take particular interest in the proposed arrangements for the employment of science and mathematics supervisors in S.3163 and science, mathematics, and language consultants in S.3187. Two years ago we [the AAAS Science Teaching Improvement Program] installed science and mathematics consultants in the geographic areas around the University of Nebraska, the University of Oregon, Pennsylvania State University, and the University of Texas. In each place there is a science consultant and a mathematics consultant. Each is an experienced and expert teacher. Each has a telephone and an automobile, and each spends most of his time in working, on an individual basis, with approximately 50 less experienced teachers in his region. He helps them with teaching problems, with subject matter problems, and with the problems of increasing their own competence and knowledge.

"This system works. Both teachers and superintendents testify to its effectiveness. We are convinced that adding a good consultant to 50 classroom teachers contributes much more to the improvement of teaching than does the addition of one more classroom teacher. We are pleased that a grant from the Carnegie Corporation enabled us to try out this system of science and mathematics consultants, and pleased to have the value of such consultants recognized in the two bills.

"As between S.3163 and S.3187, there is one aspect in which we prefer the latter. That is the matter of title; "consultant" describes the function better than does "supervisor," for a major benefit of the consultants' work comes from their getting out and consulting with classroom teachers, on the job, in their own classes, with their individual problems. Titles do not always accurately describe functions, but we are a little afraid that supervisors may spend too much time in the state capitol making rules and keeping records and answering correspondence.

"This brings up a related point. In the four states where we established consultants, we did so with full cooperation of the state departments of education, but the state university and not the state department of education is the consultant's home base. There are two important advantages in this arrangement. First, the consultant is in close touch with his scientific colleagues on the campus and is therefore a more up-to-date and better scientific representative to the teachers he serves than he would be without those regular campus contacts. Second, he helps to bring about liaison between school and college. He works with high school teachers, but he works under the direction of a committee of university scientists and educators. This arrangement brings scientists and educators closer together on the campus and brings both closer to high school problems, and this is all to the good.

"There is nothing in either S.3163 or S.3187 that would prevent the kind of relation I have described. Neither is there anything to encourage it. It is probably inappropriate to spell out any particular plan, but I hope that the states will be encouraged to base their science, mathematics, and language consultants in the appropriate subject matter department at a university wherever that arrangement is possible."

Teacher education grants; higher salaries. "Turning now to the provisions of S.3187 that provide for summer school attendance and extension course enrollment on the part of teachers, and the provisions of S.3163 that provide matching grants to states that can be used to employ additional science and mathematics teachers or to augment the salaries of such teachers, it seems to me that both represent substitutes for what is ultimately desirable. Ultimately—and the sooner the better—we should break the existing, fairly rigid salary schedules so that teachers of high merit are paid high salaries and teachers of ordinary merit are paid ordinary salaries.

"S.3163 would make a start in this direction by authorizing higher salaries for science and mathematics teachers who meet certain minimum requirements. This is not fair to the good teachers of English or History or Foreign Languages. Yet I support it because of the urgent necessity of getting better qualified science and mathematics teachers and because I fear that only by providing higher salaries for the abler teachers in some fields can we get started on the necessary changes of custom and attitude that will lead to substantial increases for the ablest teachers in all fields. Let me urge, however, that the provisions of Section 223 (b) (2) be so stated or interpreted that the required qualifications be set at a truly desirable level rather than an emergency minimum level. More will be accomplished in raising the status of teaching and setting a desirable goal for able prospective teachers by increasing substantially the salaries of the best 10 or 20 per cent of teachers than by giving minimum increases to all.

"The provisions of S.3187 are even more of a substitute for the ultimately necessary increase in teachers' salaries and adoption of a salary scale that is based on merit and that exhibits a much wider range between top and bottom salaries than now exists. There are some clearly desirable aspects of the S.3187 provisions: it is desirable for many teachers in all fields to increase their subject matter competence, and it is good to have the opportunity open to teachers in all fields. The subsidized attendance at summer schools for advanced study is clearly preferable to having teachers eke out their salaries by summer work that is unrelated to their teaching. All these things are good, yet as between paying teachers to go to school and giving the better ones higher pay for doing a good job of teaching, I personally prefer the latter proposal."

Testing and guidance. "On another proposal for improving the quality of education, I can be brief. That is the provision for strengthening the testing, counseling, and guidance program of the nation's schools and improving the quality of counseling personnel. I know enough about the situation to know that these improvements are highly desirable, for here is one way in which we can help to overcome the difficulties of having the same school have to teach students of widely divergent interests, abilities, and later educational and career plans. When such a diversity of responsibilities falls on the shoulders of a single teacher, it is not surprising that much of her teaching is pitched at the level of the average student, and much of her individual attention devoted to the students who are having the most difficulty. Under these circumstances, the abler students are too frequently left to shift for themselves. A guidance counselor can help the abler student very materially in this situation; by paying individual attention to his abilities and interests, the counselor can help him to get into the most appropriate courses, help him to plan the education that will best develop his abilities, and, in general, give him a boost that he may not get from his teachers or his parents. I am not an expert in the field of counseling, however, and hesitate to recommend the provisions of one bill over those of the other, although the longer time scale of S.3187 seems preferable, for it will take some years to train sufficient well-qualified counselors and to realize the benefits of an improved guidance program."

Graduate fellowships. "Similarly, I can be brief in commenting on provisions for graduate fellowships. This is an important provision of both S.3163 and S.3187, for as Secretary Folsom told you, the need for college faculty members is increasing in all fields, and the educational preparation of newly appointed faculty members is declining. In view of the fact that the National Science Foundation already has an excellent program of fellowships in the sciences, under which the Fellows can enroll in any university that accepts them, I urge consideration of the provisions of S.3163, for those provisions will, I believe, contribute more effectively to the building up of additional graduate education opportunities of high quality all over the nation than will the fellowship plans of S.3187. Whichever of these systems is adopted, I strongly urge retention of the proposal, in both bills, to make fellowships available to students in all fields of advanced study."

Foreign languages. "The teaching of foreign languages is outside my area of competence, so I will not try to choose between the two bills. But let me commend the authors of both for recognizing the importance of giving our students better facility in languages other than English. In terms of the literature they must read, the meetings they attend, and the colleagues with whom they can profitably discuss their work, scientists constitute one of the most international professional groups in the world. Yet too many of them are unable to carry on a conversation in any language other than English."

Scholarships. "I have left the topic of scholarships to the last, for there are several quite different things I want to say on that topic. There are three principal reasons for granting scholarships. One is to attract students into a field in which there might otherwise be a shortage. A second is to aid needy students to secure an education. The third is to encourage and reward scholarship of high quality. Each of these points should be considered in deciding upon the nature of a desirable scholarship program.

"First, the use of scholarships to attract students into fields in which there might otherwise be shortages. We need talent in science, mathematics, and engineering. But we also need talent in many other fields. Consequently, I endorse the statements in both S.3163 and S.3187 that students who expect to specialize in any field of study will be eligible for scholarships. But I would go farther than either bill does in this respect; I recommend that the emphasis on science and mathematics be stricken out of the scholarship provisions entirely. Where a special need is evident, it is appropriate to give specialized fellowships at the graduate level. In the high school, it is proper now to give special attention to the teaching of science and mathematics, not because those subjects are more important than, say, English, but because it is important to redress some of the imbalances that we have allowed to develop. But in offering a scholarship to a boy or girl who is about to graduate from high school, let us not try to purchase interests that have not developed naturally and that may not be permanent. The Board of Directors of the American Association for the Advancement of Science has discussed this problem in some detail and is firmly on record as recommending that scholarships be awarded on the basis of merit, without consideration of the proposed field of specialization. I might add that the Educational Advisory Board of the National Academy of Sciences, the Engineering Manpower Commission, and the Scientific Manpower Commission have adopted exactly this same position.

"The second use of scholarships is to aid needy students to secure an education. It is true that there are bright boys and girls who are good students, who would like to go to college, but who cannot afford to do so. But it is also true that their number is usually overestimated. The percentage of high school graduates who enter college has been rising in recent years, and most of the statistics that are quoted on this point are out of date. There are no thoroughly good, nationwide statistics on this matter, but recent studies by the Office of Education, the Educational Testing Service, and one or two states indicate that of the top 10 per cent of high school graduates, about 80 to 90 per cent enter college, and that of the top quarter of high school graduates, two thirds or more enter college.

"What of the others? Some go into technical training institutions. Some of the girls take training as nurses and others marry. And an important fraction do not want to go to college. It is still true that some need partial help and others need full support, but there are already scholarships available from other sources, and the number of students who would go to college if one of these bills becomes law but who would not in the absence of such legislation is not large. Consequently, it seems to me that there are other and more effective ways to use a Federal scholarship program.

"It is appropriate in this connection, however, to consider the student loan provisions of S.3187. I hope that these provisions will be adopted so that the United States can give a substantial student loan arrangement a really good try. It is frequently said that loan funds go begging on many campuses now, and while this is true, this is not the whole story. Some of the available loan funds provide only relatively small loans that must be repaid quickly. They are useful in tiding a student over a temporary difficulty, but are not useful in financing an education. There has never been as generous and as widely available an opportunity to borrow money for educational expenses as is proposed in S.3187. That may be one of the principal reasons why student loans have never become popular in the United States.

"I would also like to support the forgiveness feature of the loan program for recipients who later become teachers. Again, this is a substitute for the ultimately desirable goal of paying teachers salaries commensurate with their abilities and worth. But it is unrealistic to expect immediate adoption of such a salary scale. In the meantime, the opportunity to cancel 20 per cent of the total loan for each year spent in teaching should aid the schools greatly in securing additional teachers.

"The third function of a scholarship program is to encourage and reward scholarship of high quality. This is the function that should be given greatest emphasis. A scholarship of $500 or $1000 a year for four years is a substantial award. A national scholarship program is a sign of national interest in academic excellence. Both the winners and those who compete but fail to win will be more likely to go to college because of their heightened interest and application. In order to make the program most effective in improving scholarship and raising educational standards, I suggest that scholarship winners be selected on the basis of a national examination that emphasizes the fields of subject matter knowledge that are of most importance as a basis for good college work. Administration of these examinations can be local and there can be state quotas, but the national character of the examinations will enhance their prestige and motivational value.

"Senator Pastore has introduced a bill, S.1021, that proposes to offer scholarships to students who make sufficiently high scores on an examination covering high school mathematics. In earlier testimony, Professor I. I. Rabi has endorsed this idea. It is an excellent idea, for it would place clear emphasis upon the universal importance of a sound knowledge of mathematics whatever the field of specialization the student later entered. The idea can well be extended, however, so that scholarship winners would be selected on the basis of an examination covering mathematics, English, and perhaps a modern foreign language and science. Such subjects as these are the core of a good background for college work. They are the subjects we want to emphasize in the education of bright students. A scholarship program that placed such clear stress on these fundamental fields of knowledge would motivate students to do well in their high school work, would offer tangible proof to teachers, students, and parents of the importance attached to the basic college preparatory subjects in the high school programs of bright students, and would leave the students completely free to choose their own fields of specialization after they entered college. Here is a method by which a scholarship program can both motivate individual students to do well in their work, and at the same time encourage teachers, school administrators, and school boards to provide high quality instruction in the subjects that are of greatest value to bright students.

"In conclusion, I would like to commend the wording of the statement of purposes of S.3187. I refer particularly to the words, '. . . assure the intellectual preeminence of the United States. . . .' This is a noble objective. I hope that we mean it, and that we enact legislation that will asure the intellectual preeminence of the United States."

A Security Case in Britain

A British scientist suspended from his position on security risk charges has won his appeal against dismissal and has returned to work. According to a recent Reuters dispatch from London, "Mr. Z" was suspended 4 days before Christmas because he was judged to be "susceptible to Communist pressure." A special investigation officer had reported, after a routine interview to which all civil servants engaged on secret work are periodically subjected, that Mr. Z had "extreme pro-Russian sympathies." Listed against him were the following statements he made to the investigating officer's questions: that what was being done in Hungary by the Russians was no worse than the British government was doing in Cyprus; that there was no more repression in Russia than in other countries; and that Russia was living "in a world opposed to her."

Mr. Z, who was on full pay during his suspension, appealed to the three advisers appointed by the Prime Minister to hear appeals against security dismissal cases. It is reported that he denied that he was pro-Russian and pointed out that he had merely expressed his views freely and honestly in answer to the questions put to him.

Atmosphere Entry Simulator

A new laboratory device capable of simulating the extremely high temperatures and thermal stresses encountered by missiles and space craft flying at great speeds in the earth's atmosphere is announced in the annual report of the National Advisory Committee for Aeronautics. The NACA calculates that a model only 0.36 inches in diameter and weighing 0.005 pound can simulate the reentry flight of a full-scale 4000-mile range missile of diameter 3 feet and weight 5000 pounds.

The atmosphere entry simulator was designed by Alfred J. Eggers, Jr., of the NACA Ames Aeronautical Laboratory, Moffett Field, Calif, Another Ames scientist, H. Julian Allen, conceived the principle of blunt shaping of missile nose cones as a means of minimizing the heating factor.

The main element of the simulator is a trumpet-shaped nozzle through which air at supersonic speed undergoes changes in density from one end of a 20-foot passage to the other. The missile model is launched from a high velocity gun against the air stream. While flying through the nozzle test chamber, the model encounters air of increasing density, thus duplicating the flight course of a full-scale missile. The simulator can provide a variation in density over a range of 100,000 feet. It is used at altitudes up to a maximum of 200,000 feet.

A pilot model of the simulator is in use at the Ames Laboratory and a larger version is nearing completion. The NACA reports that the new reentry simulator will be in operation later this year for use on problems related to missile and space craft research.

News Briefs

At a ceremony last month at Bonn University, the German Council of Arts and Sciences (*Wissenschaftsrat*) was officially established. According to an agreement made between the Federal Government and the states, this council is to coordinate all West German plans for the advancement of the arts and sciences, to draw up a program of matters to be given attention, and to submit recommendations about how available funds are to be used.

* * *

The United States will operate four scientific stations in Antarctica in 1959. Rear Admiral George Dufek announced recently that the South Pole, Byrd, Hallett, and McMurdo Sound stations had been selected for further operations at the conclusion of the International Geophysical Year. Three bases will be discontinued: Little America, Ellsworth, and Wilkes. Little America, however, will be used as a weather-reporting station, and its snow runway will be maintained as an emergency landing strip for flights to the McMurdo Sound and Byrd stations.

* * *

The story of Archimedes, Greek mathematician, physicist, and inventor who discovered the underlying principle of specific gravity, will be seen on Telephone Time's *Man of Principle* over ABC-TV on 25 March at 9:30 P.M. EST and PST (8:30 P.M. other time zones).

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The National Merit Scholarship Corporation has announced that future Merit Scholarship competitions will begin with the testing of high school juniors rather than seniors. Thus, the 1958–59 program will begin this spring with a nationwide examination for second-semester juniors and first-semester seniors on 29 April 1958. Three previous national competitions have started with fall examinations, administered to members of the senior classes. The new junior-year test will enable students to understand more about their academic strengths and weaknesses in time to apply the information in choosing courses in the senior year.

Scientists in the News

CLAY G. HUFF, head of the division of parasitology in the Naval Medical Research Institute, Bethesda, Md., was awarded the Navy Distinguished Civilian Service Award at ceremonies in the office of the Assistant Secretary of the Navy, Fred A. Bantz, on 10 February. Huff's citation read:

"For exceptional and exemplary contributions which have added significantly to the prestige of naval medical research in the field of parasitology. You have advanced basic research on the tissue phase of the malarial parasite, particularly the development of the far-reaching implication of the exoerythrocytic stages on the important phenomena of host and parasite susceptibility and immunity. You have established yourself as a world authority on the morphology of exoerythrocytic stages of plasmodia from a wide variety of both warm and cold-blooded vertebrate hosts. Your distinguished achievements in the tissue phase of the malarial parasite are a matter of wide implication to military medicine and to the civilian populace since they represent milestones in the field of medical parasitology and tropical medicine."

JOHN R. DUNNING, dean of the Columbia University Engineering School and the first American scientist to demonstrate uranium fission, was one of the recipients of the annual Stevens Honor Award at a recent banquet of the Alumni Association of Stevens Institute of Technology.

GEORGE GAYLORD SIMPSON has asked to be relieved of his administrative duties as chairman of the department of geology and paleontology at the American Museum of Natural History in order to devote his time more fully to research, teaching, and his position as curator of fossil mammals and birds. EDWIN H. COLBERT, curator of fossil reptiles and amphibians, who has been acting for Simpson, has been appointed chairman. In August 1956, while on an expedition to Brazil, Simpson was the victim of a serious accident, as a result of which his activities have been necessarily limited.

ROBERT BROWN, botanist of Oxford University, will lecture in May at the University of Texas on cell growth and differentiation.

Recipients of the sixth annual Glycerine Research Awards of the Glycerine Producers Association are JAMES TULLIS of the Blood Characterization and Preservation Laboratory, Jamaica Plain, Mass., first award of $1000 for his work in the glycerine freezing of human blood for long-term preservation; GUIDO MARINETTI, assistant professor of biochemistry at the University of Rochester School of Medicine and Dentistry, second award of $300 for work on the analysis, biosynthesis, and chemical structure of phospholipids, derivatives of glycerine found in the tissue of living cells; and HENRY R. SALLANS and C. G. YOUNGS of the Prairie Regional Laboratory, National Research Council, Saskatoon, Saskatchewan, Canada, third award of $200 for their work on the glyceride composition of fats.

ARTHUR S. TAMKIN, formerly a psychologist with the Veterns Administration, has been appointed director of research at the Columbus Receiving Hospital for Children, Columbus, Ohio. He is conducting a program of research on the evaluation of psychiatric treatment for the emotionally disturbed child.

JAMES A. SHANNON, director of the National Institutes of Health, received the New York University College of Medicine Alumni Association's 1958 scientific award on 22 February at ceremonies dedicating the new Alumni Hall of New York University–Bellevue Medical Center. He was cited for "outstanding achievements in the fields of renal physiology, malarial control and national administration of medical research."

NEAL MILLER, James Rowland Angell professor of psychology at Yale University, has been appointed chairman of the Division of Anthropology and Psychology of the National Academy of Sciences–National Research Council, effective 1 July.

SVEND M. CLEMMESEN of Copenhagen, Denmark, will be the first Louis J. Horowitz visiting professor of physical medicine and rehabilitation at New York University–Bellevue Medical Center's College of Medicine. Clemmesen, who will be at the Medical Center during the month of April, is in charge of the department of physical medicine and rheumatology, Kommunehospitalet, Copenhagen, and is a lecturer at the University of Copenhagen.

GEORGE H. NELSON has been named president of Law-Barrow-Agee Laboratories, Inc., of Atlanta, Ga., and the firm has been renamed Law Engineering Testing Company. THOMAS C. LAW, president and founder of the company, will become chairman of the board. Nelson has been executive vice president since the company's founding in 1948.

Recent Deaths

COMFORT A. ADAMS, Philadelphia, Pa.; 89; Lawrence professor of engineering at Harvard from 1914 until 1936, dean of its school of engineering in 1919, and Gordon McKay professor of electrical engineering in 1935–36; 22 Feb.

HENRYK ARCTOWSKI, Washington, D.C.; 86; specialist on world weather and retired research associate, Smithsonian Institution; before coming to U.S. in 1939, head of the department of meteorology and climatology at the University of Lvov, Poland; 22 Feb.

EGBERT F. BULLENE, San Francisco, Calif.; 63; retired major general and former chief of the Army's Chemical Corps; 22 Feb.

JOHN G. B. CASTOR, San Francisco, Calif.; 49; associate professor of enology and associate microbiologist in the Experiment Station of the College of Agriculture at Davis; 4 Jan.

CHARLES K. DEMING, New Haven, Conn.; 64; surgeon with the Yale Medical School and the Department of University Health; specialist in industrial medicine; 21 Feb.

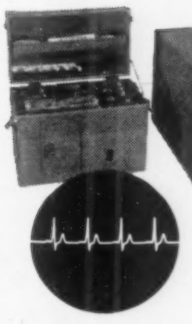
ABRAHAM HOFFMAN, Fort Lauderdale, Fla.; 83; professor of orthodontics at the University of Buffalo from 1907 to 1919, head of the orthodontics department at New York University from 1924 to 1927, and head of the orthodontics department at the Northwestern University Dental School from 1927 to 1939; 24 Feb.

THOMAS H. HOGG, Toronto, Ont., Canada; 73; electrical engineer and former chairman of the Hydro-Electric Power Commission of Ontario; 25 Feb.

WILLIAM F. LORENZ, Madison, Wis.; 76; professor emeritus of psychiatry of the University of Wisconsin; pioneer in the use of carbon dioxide gas for the treatment of psychoses; 19 Feb.

FREDERICK A. WATERMAN, Tucson, Ariz.; 53; assistant professor of zoology at the University of Arizona; formerly associate professor of biology at Wayne University; 30 Dec.

THOMAS W. STEVENSON, JR., Mount Kisco, N.Y.; 53; noted plastic surgeon who specialized in restoring hands; professor of clinical surgery at Columbia University's College of Physicians and Surgeons; 22 Feb.



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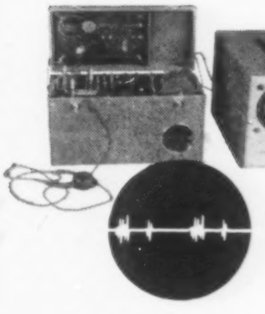

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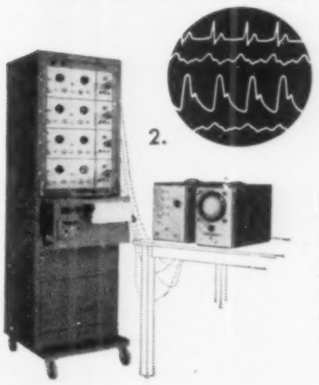

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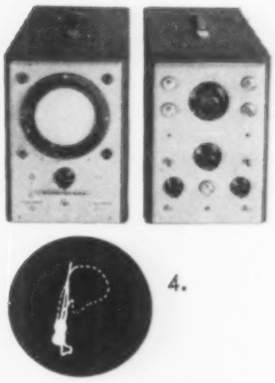

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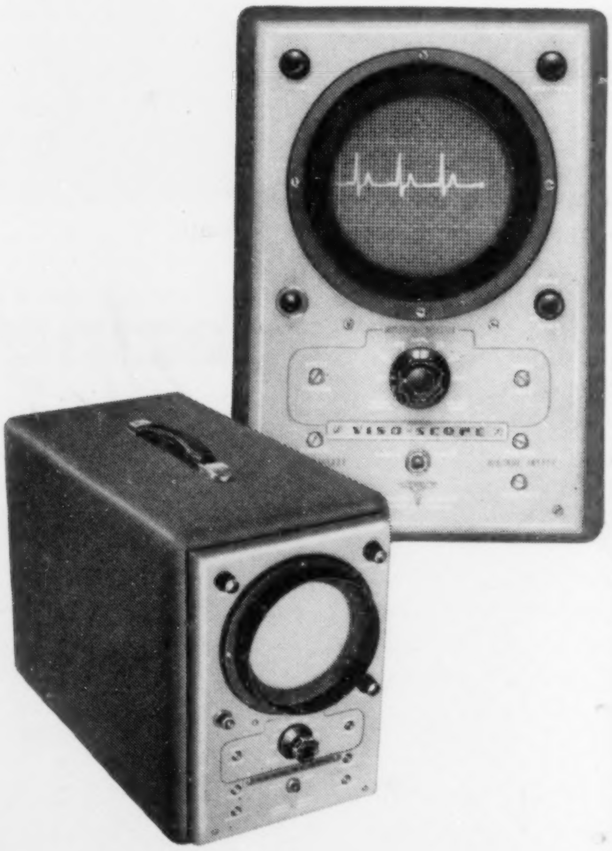

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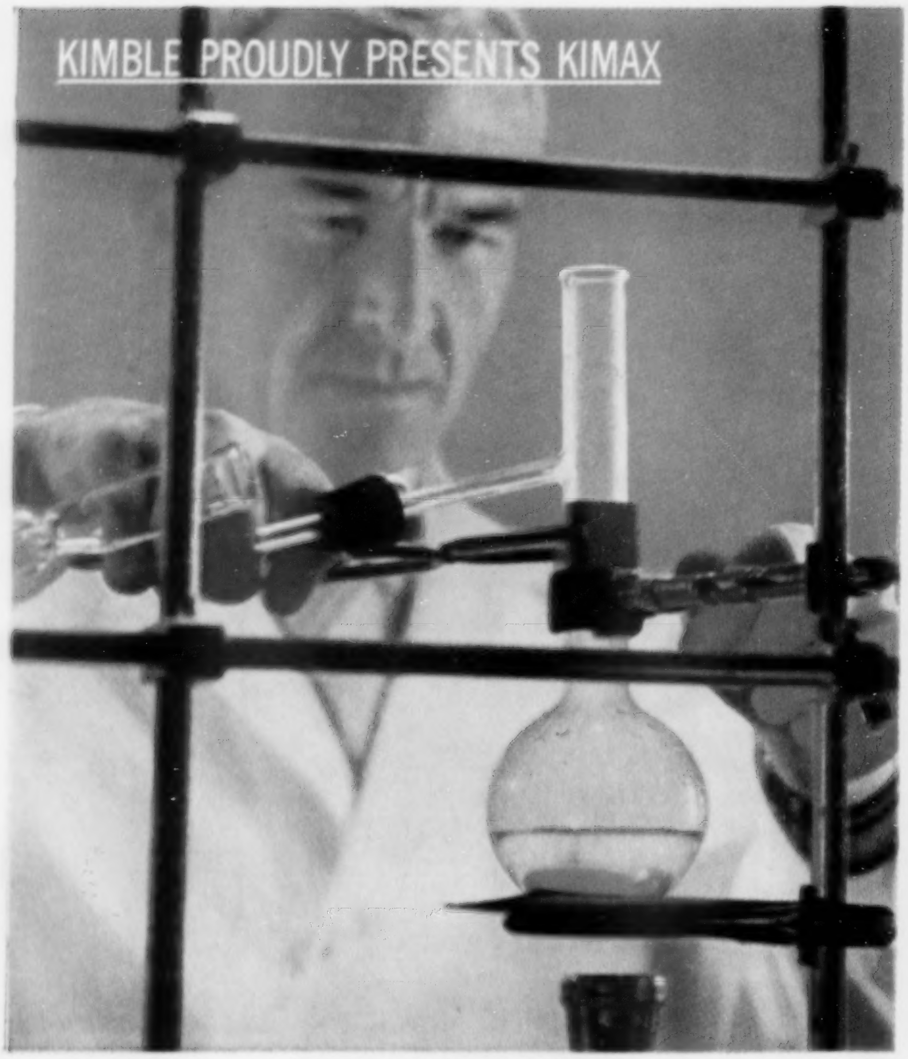
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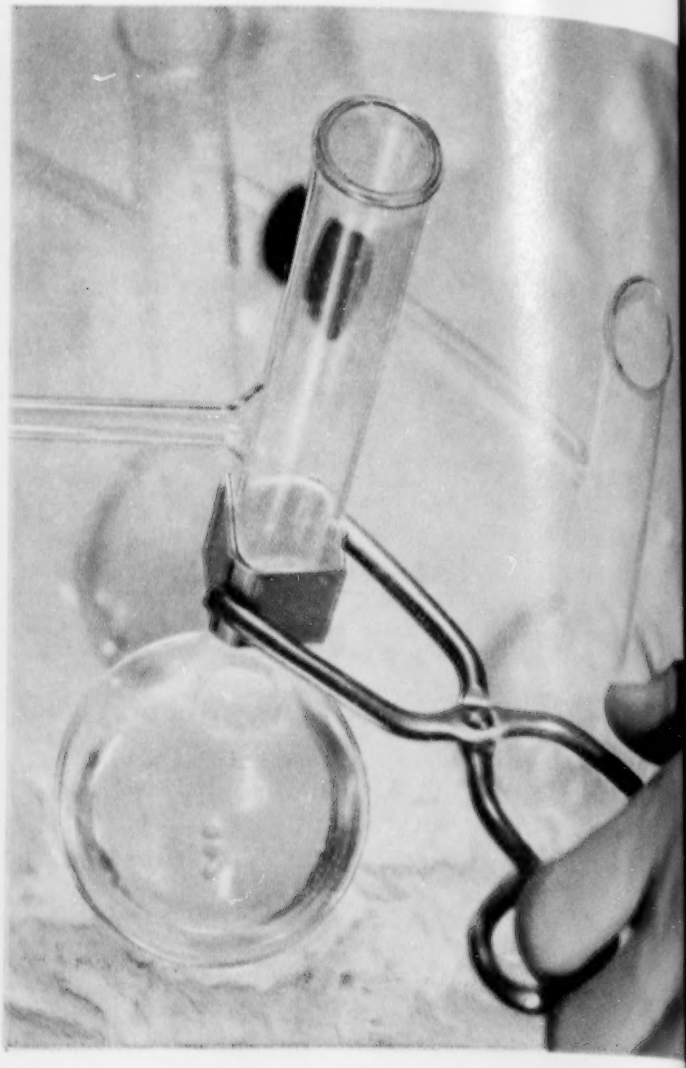

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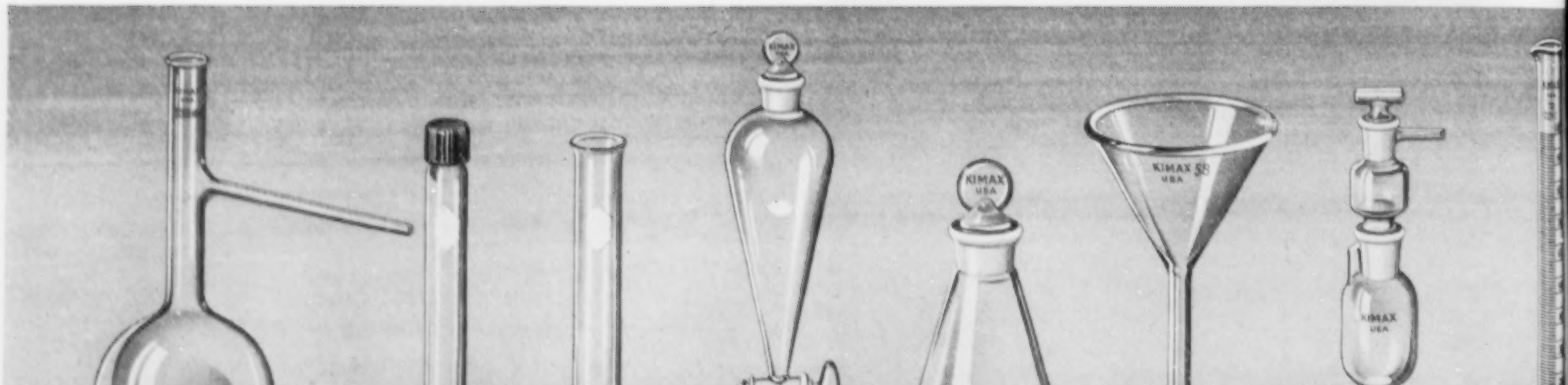
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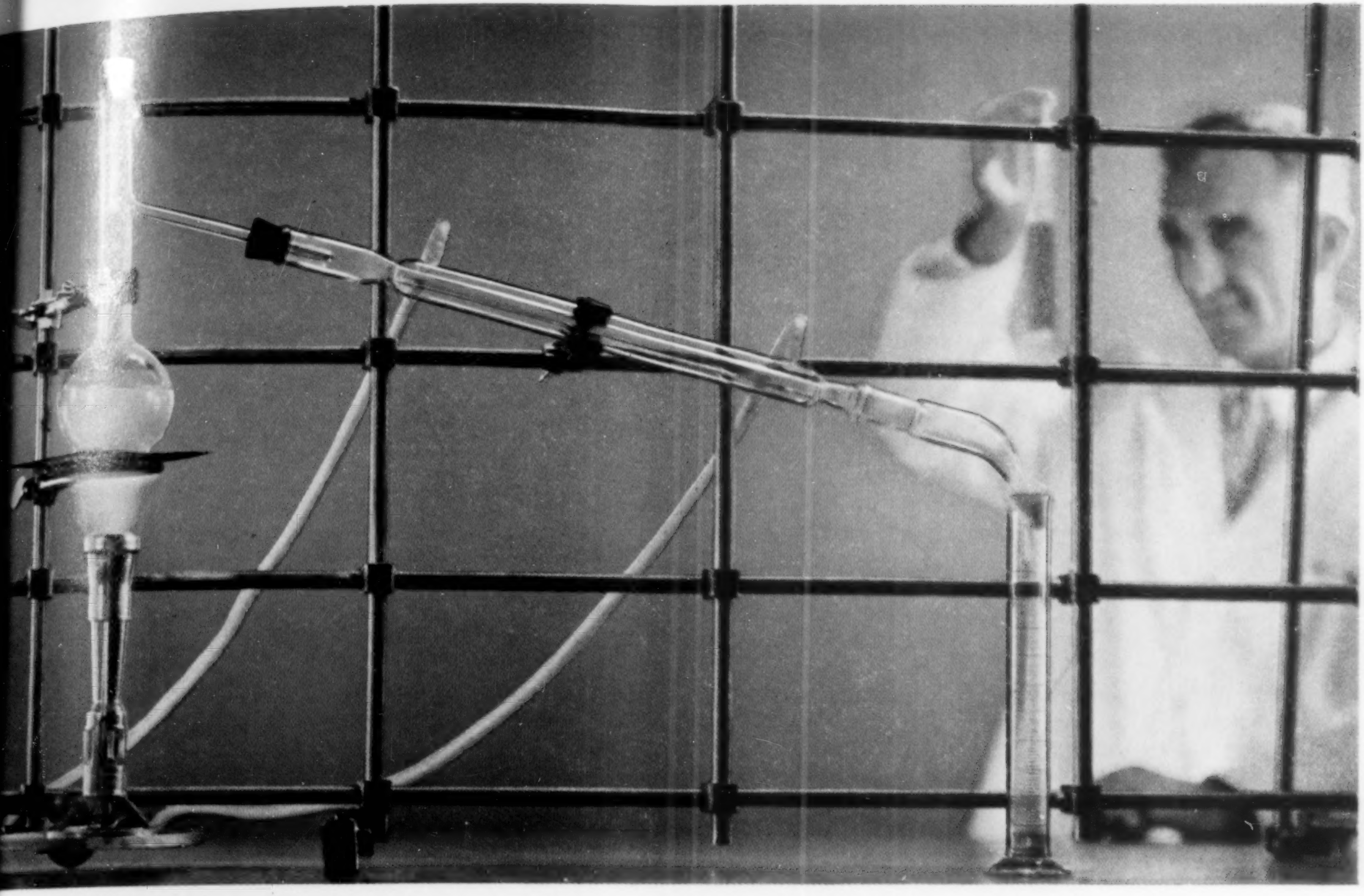

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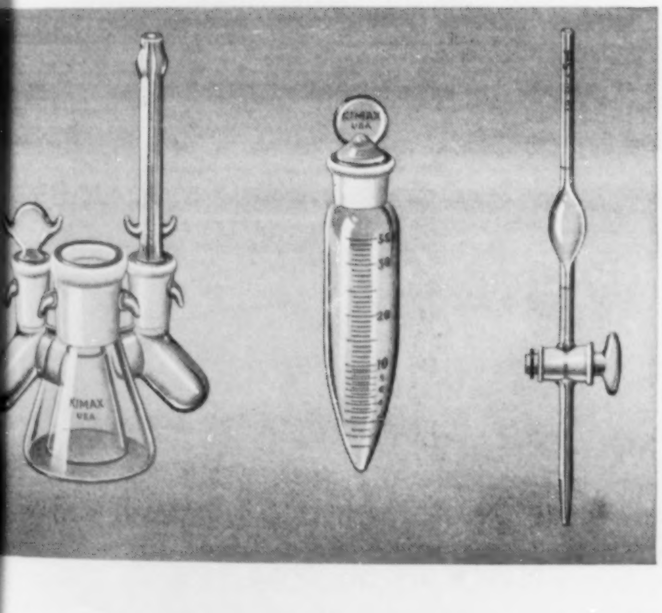

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Reports

Constitutional and Environmental Interactions in Rearing of Four Breeds of Dogs

The initial intention of the present study was to determine the relative effects of "indulgent" and "disciplinary" modes of rearing in dogs, with particular emphasis on how each method affects the obedience of the animal at maturity. The work derived from the extensive observations of children made by D. M. Levy (*1*), who has shown that overindulgent rearing may lead to psychopathy, a syndrome which involves an abnormal inability to inhibit one's impulses. The study described in this report was an attempt to deal experimentally with Levy's concept. As will be seen, the results are of interest aside from their reflection on this initial hypothesis.

Eight litters of four pups each were used. These included two litters each of Shetland sheep dogs, basenjis, wire-haired fox terriers, and beagles. Following weaning at 3 weeks of age, each litter of four was divided into two pairs equated as closely as possible on the basis of sex, weight, activity, vocalizations, maturation of eyes and ears, and reactivity to a startling stimulus. Each member of one pair was thereafter indulged, and each member of the other pair was disciplined, during two daily 15-minute periods from their third to their eighth week of age.

Indulgence consisted of encouraging a pup in any activity it initiated, such as play, aggression, and climbing on the supine handler. These pups were never punished. By contrast, the disciplined pups were at first restrained in the experimenter's lap and were later taught to sit, to stay, and to come upon command. When still older they were trained to follow on a leash. The pups were handled and tested individually by a single experimenter throughout the study. They lived in pairs in isolation boxes the remainder of the time, where members of indulged and disciplined pairs received identical treatment. The results were as follows.

At 8 weeks of age each pup was subjected to the following test: Each time a pup ate meat from a bowl placed in the center of a room, he was punished with a swat on the rump and a shout of "no!" After three minutes the experimenter left the room and, observing through a one-way glass, recorded the time that elapsed before the pup again ate. The results over 8 days of testing are summarized in Fig. 1. Basenjis tended to eat soon after the experimenter left, the method of rearing having no statistically significant effect. Shetland sheep dogs tended to refuse the food over the entire 8 days of testing. Again, the fashion of rearing had no significant effect. Beagles and wire-haired fox terriers, however, differentiated into two significantly disparate groups, depending on the condition of rearing. The Friedman nonparametric analysis of variance (*2*) indicates that the indulged pups took significantly longer to return to the food than did the disciplined pups ($p = 0.001$). Thus, as measured in this test, essentially the same differences in treatment had a decisive effect upon only two breeds.

Can characteristics of the breeds explain the differences in performance on this test? It was clear that, during training, beagles and wire-haired terriers were strongly oriented to the experimenter and sought contact with him continuously. Basenjis, by contrast, were interested in all phases of the environment and often ignored the experimenter in favor of inanimate objects. Shetland sheep dogs showed yet another pattern; all became fearful of physical contact with the experimenter and tended to maintain distance from him. We see, then, that the two breeds that were highly attracted to the experimenter differentiated as a result of the mode of rearing, whereas the breeds that exhibited aloofness (basenjis) and excessive timidity (Shetland sheep dogs) did not. Apparently it was the strong (constitutional) attraction in interaction with indulgent treatment that enhanced the effectiveness of later punishment. It should be noted that basenjis and Shetland sheep dogs were not entirely unaffected by the differential treatment. The scores of *all* indulged animals were significantly different from those of their disciplined counterparts on five of ten tests administered. In general, these tests indicated that the indulged pups were more active, more vocal, less timid (although more easily inhibited with punishment) than the disciplined pups.

A test of individual reactions to veterinary treatment based on vocalizations and the degree of activity during routine injections indicates that indulged pups were more vocal and active than disciplined pups in their protest ($p = 0.02$, Mann-Whitney) and that basenjis were more vocal and active than the other three breeds ($p = 0.01$, Friedman analysis of variance). It has been found at our laboratory that basenjis generally gain higher scores on this test than other breeds; hence these data suggest that similar behavior may be due in one instance to constitution (as in the basenjis) and in other instances to the conditions of rearing.

A test of the level of activity, in which the pups were observed from a hidden vantage point for 10 minutes, was administered. The testing area was 10 by 20 ft and was demarcated into eight squares of 5 by 5 ft each. In this setting,

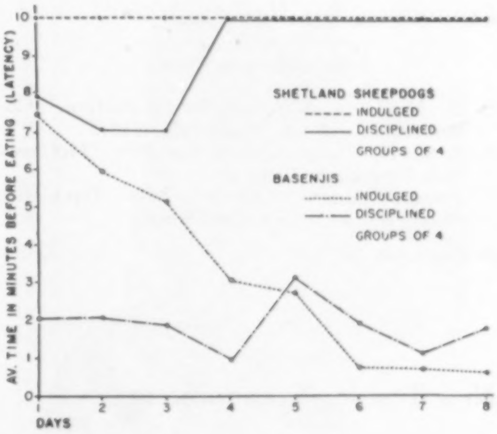

Fig. 1. Performance of 8-week-old puppies on the "inhibition-to-eating" test (see text for details of procedure).

All technical papers and comments on them are published in this section. **Manuscripts should be** typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

disciplined Shetland sheep dogs showed significantly less activity than any other animals ($p = 0.001$, Friedman analysis of variance). In another test the experimenter sat silently in a room for 10 minutes and recorded the amount of time the pups spent in contact with him. In this test the *indulged* Shetland sheep dogs differed significantly from all other dogs in that they rarely approached the experimenter ($p = 0.001$, Friedman analysis of variance). From these results it is clear that a specific test for a specific breed may facilitate expression of the effects of early rearing.

The conditions of rearing were continued over a second period, when the pups were 11 to 15 weeks of age, and all tests were readministered, with essentially the same results.

In the follow-up observations and tests, the indulged beagles, in contrast to all other animals, underwent dramatic changes, in time, although all animals were maintained under standard conditions. On a weekly test in which the time taken to catch each animal was recorded, these animals became exceedingly shy and wary of being caught when approached by various human beings, including the experimenter ($p = 0.05$, t test). Thus, it appears that changes in the behavior of certain animals may occur that are seemingly independent of the current environment and belatedly dependent, instead, upon the mediation of past experiences.

D. G. Freedman*
Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine

References and Note

1. D. M. Levy, *Maternal Overprotection.* (Columbia Univ. Press, New York, 1943).
2. S. Siegel, *Non-parametric Statistics.* (McGraw-Hill, New York, 1956).

* Present address: Mount Zion Psychiatric Clinic, San Francisco, California.

26 December 1957

New Test for Tranquilizers

The clinical success of the tranquilizing drugs has yet to be matched by a comprehensive experimental account of their behavioral effects. However, there has been impressive progress in certain areas. For example, a number of studies have dealt with the effects of tranquilizers on the behavior of experimental animals in the presence of stimuli associated with punishment ("anxiety" or "fear" situations) (*1, 2*). Tranquilizers have also impaired animal performance in discrimination tasks (*3*). The present report describes a somewhat different approach to "tranquilization." The findings suggest an aspect that is not associated with punishment or "fear reduction" and that is expressed in improved rather than impaired performance. Pigeons have served as subjects in this work.

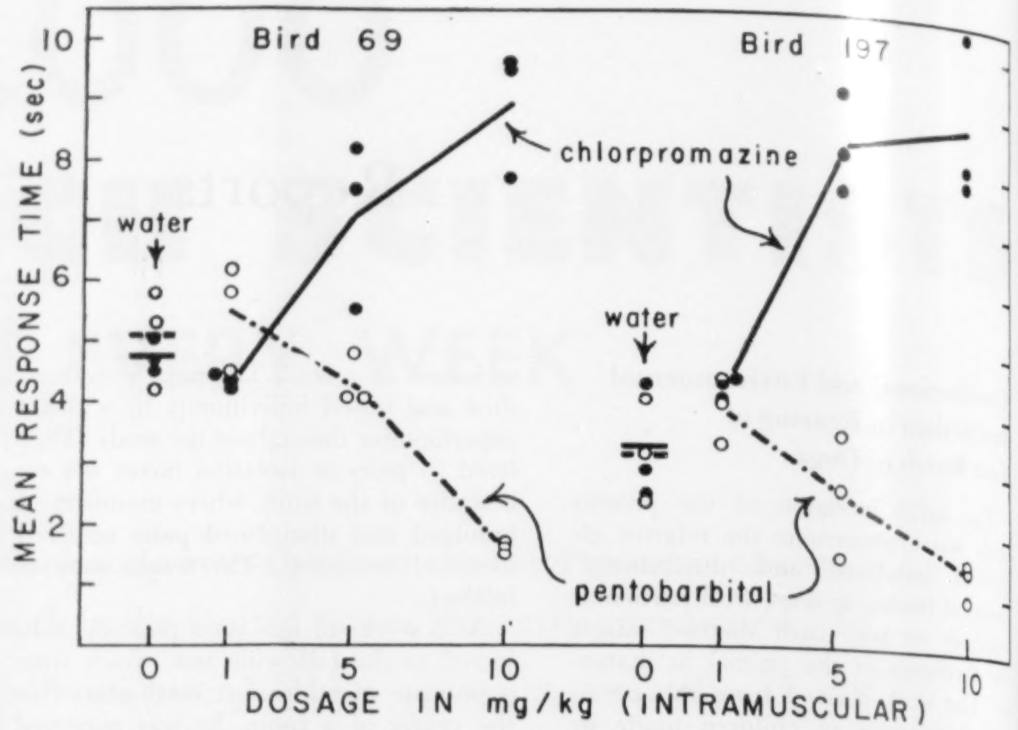

Fig. 1. Dose-response curves from two birds. Individual sessions appear as circles and dots; lines join the means of three sessions. The higher the curve, the longer, on the average, the bird stood still to gain food reinforcement.

The basic idea of the method may be stated simply. A pigeon is trained to stand still in a particular location. The longer it stands continuously in the designated spot, the more likely it is to receive food reinforcement. The bird's performance of this "standing response" is recorded as a function of drug dosage.

The method has been applied in a brief study as follows. The bird was placed in a closed, cubical chamber. A food magazine set in the front wall of the chamber operated automatically to present grain to the bird. Small photocells were located on one side wall and on the rear wall of the chamber. The cells were placed at about the height of the pigeon's head when it stood erect. Opposite the cells, in the front wall and in the other side wall, were small electric lamps. When the bird stood in a circumscribed area near the center of the chamber, its head cast a shadow over both photocells simultaneously. When the bird was in any other position, one or both cells received light from the lamp opposite. If the bird stood in the correct position and cut off light continuously from both cells for a sufficiently long period, it gained access to the food magazine for 5 seconds. A translucent disk on the front wall of the chamber glowed whenever the bird was in the right position. The length of time that the bird stood continuously in the correct position is defined as the "response time."

The hungry pigeon (weighing about 80 percent of the weight it attained when it was allowed to feed freely) was trained as follows. First it was allowed to become familiar with the food magazine, and then it was given food whenever it happened by chance to stand in the correct position for half a second or so. As in other instances of operant conditioning (*4*), the bird spent more and more time in the correct position, and the response time required to bring food was gradually increased.

Each experimental session lasted 2 hours. During this time, the bird received approximately 30 food reinforcements, averaging one every 4 minutes. This schedule was maintained by varying the response time required for reinforcement. With each reinforcement, the response time required to bring food the next time was increased by 2 seconds. Every 4 minutes the required response time was automatically reduced by 2 seconds, regardless of the bird's behavior. Thus, if the bird averaged more than one reinforcement in 4 minutes, it gradually increased the response time required, while if it averaged fewer reinforcements, the response time gradually decreased. No matter how "well" the pigeon performed (that is, how long, on the average, it stood continuously in the critical position), an equilibrium was reached such that the bird was reinforced about every 4 minutes. (Of course, if the bird had not performed the correct response at all it would not have been reinforced, but this situation did not arise in the experiment described in this report.) Counters totaled the number of response times that fell in each of ten intervals covering the range from 0 to 30 seconds. The average response time for each 2-hour session was computed from these totals.

Although the correct position was such that the bird was not required to stand perfectly still but could move its head somewhat while remaining within bounds, the task proved a difficult one. Well-trained birds stood for an average of only 5 to 6 seconds before they moved away. While standing, they appeared to be very excited and commonly made slight pecking movements.

In testing sessions, the drug or control water dose was administered intramuscularly 10 minutes before the experimental session began. The results of a series of sessions with two birds are shown in Fig. 1. Dose-response curves for chlorpromazine, a widely used tranquilizer, and pentobarbital, a hypnotic, appear together, with their associated water controls. The average response times during three sessions at each dosage are connected by lines, while individual sessions appear as separate dots. Dosage, in milligrams per kilogram, is shown on the abscissa.

It is evident that chlorpromazine substantially lengthened the response time that these birds were able to sustain, while pentobarbital reduced the response time (5). Since the birds were highly excited, one may appreciate at a common-sense level why a "tranquilizer" might enable the bird to "stand still" for an extended time. Neither drug, it should be noted, was given in doses large enough to produce gross behavioral effects such as ataxia. The difference in the direction of effect of the two drugs is of some interest, because these drugs have produced effects in the same direction (though of different magnitude) both in conditioned avoidance and in discrimination experiments (1, 3). It remains to be seen whether other tranquilizers will produce effects similar to those of chlorpromazine, or whether such effects will be matched by drugs not ordinarily classed as tranquilizers. If the promise of the initial results is borne out, it may prove profitable to study other varieties of "continuous" responding and perhaps to investigate the effects of tranquilizers in other areas that do not involve "anxiety" or "fear."

DONALD S. BLOUGH
National Institute of Mental Health, Bethesda, Maryland

References and Notes

1. L. Cook and E. Weidley, *Ann. N.Y. Acad. Sci.* 66, 740 (1957).
2. M. Sidman, *ibid.* 65, 282 (1956).
3. D. S. Blough, *ibid.* 66, 733 (1957).
4. C. B. Ferster, *Psychol. Bull.* 50, 263 (1953).
5. These results have been confirmed in studies with a third pigeon. The aid of William H. Jones in running the experiments is acknowledged.

6 November 1957

Hormone-Induced Ovarian Development in Mosquitoes

The common house mosquito, *Culex pipiens* L., is said to be anautogenous in that the adult female requires a blood meal to form eggs. A closely related form, referred to as *Culex molestus,* is autogenous; these females are able to produce a small batch of eggs without having imbibed blood or any other food.

It has been stated that a blood meal or some blood fraction is necessary to initiate egg formation in some mosquitoes (1).

Twohy and Rozeboom (2) have shown that *C. molestus* contains more nutritional reserves than *C. pipiens* if the two species are reared under comparable conditions, but they agree with Clements (3) that nutritive conditions per se are not responsible for initiation of autogenous ovarian development. However, the possibility that the ovarian development of mosquitoes, like that of some other insects, is controlled by hormones has been suggested. The experiments that are reported here (4) were specifically designed to clarify this issue.

The undeveloped ovaries of *C. pipiens* were removed 5 to 7 days after the females had emerged [Fig. 1 (3)] and were transplanted into recently emerged *C. molestus* females. Four days later the *C. molestus* females were dissected, at which time the transplanted ovaries were seen to be fully developed [Fig. 1 (4)]. Undeveloped ovaries of *Aedes aegypti* (also an anautogenous mosquito) which had been transplanted into recently emerged *C. molestus* females also were shown, on dissection, to have become completely developed after 4 days. On the other hand, ovaries of *C. pipiens* or *C. molestus,* when transplanted into *C. pipiens* females, do not develop if the hosts are denied a blood meal. Hence, the factors responsible for initiation of development are not inherent in the ovary.

It has been shown for a number of insects that ovarian development is controlled by hormones and that a hormone produced by the corpora allata is involved (5). In the light of these findings, the corpora allata were removed from *C. molestus* females within 24 hours after emergence and transplanted into 5- to 7-day-old female *C. pipiens*. This operation is technically rather difficult but was successful on five occasions. These females were dissected 5 days after the transplantation and, in each case, contained fully developed eggs [Fig. 1 (1, 2)]. The evidence thus suggests that ovarian development is induced by a gonadotropic hormone secreted by the corpora allata. The young *C. molestus* female is apparently able to release this hormone without taking a blood meal, while *C. pipiens* needs to ingest blood for the release of the allatum hormone.

Ligature experiments by Detinova (6), Clements (3), and Gillette (7) and by me have provided evidence that a factor in the brain, presumably hormonal in nature, is also involved in the maturation of the ovary. The evidence presented here indicates that the corpora

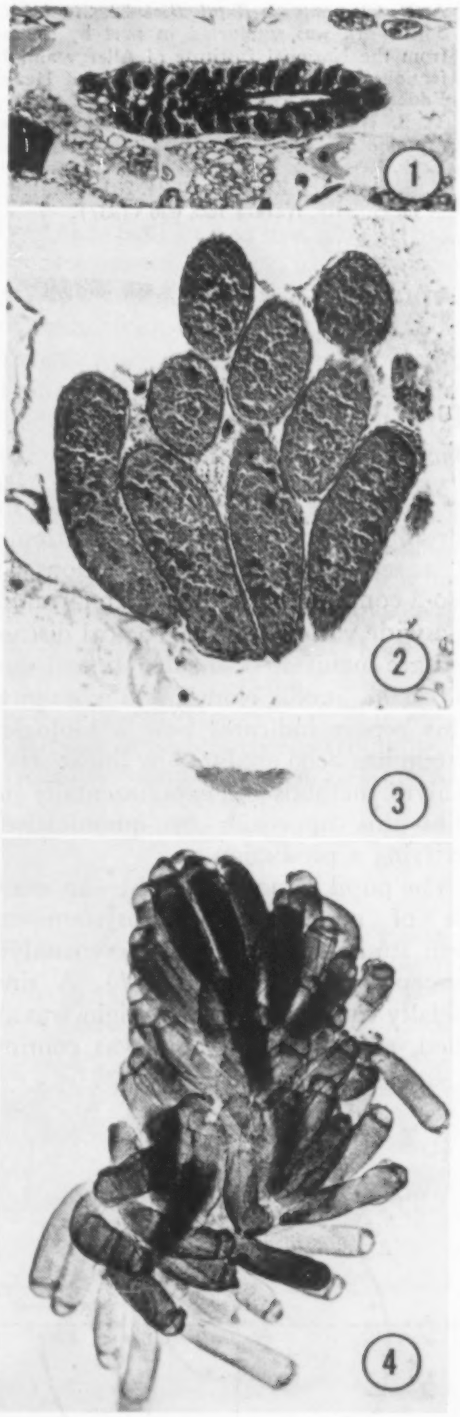

Fig. 1. (1) Section through ovary of a 2-day-old adult *C. pipiens,* showing condition of resting ovary in adult mosquito not fed on blood. (2) Section through part of adult *C. pipiens* ovary, showing fully developed eggs 5 days after corpora allata transplantation. (3) Total mount of ovary of a 5-day-old adult *C. pipiens* not fed on blood, showing size of ovary at time of transplantation. (4) *Culex pipiens* ovary 4 days after transplantation into a 24-hour-old *C. molestus* host. Note fully developed eggs. Compare with ovary in (3).

allata are also a link in the humoral cycle initiating ovarian development in mosquitoes.

Joseph R. Larsen
Division of Medical Entomology, Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland

References and Notes

1. T. Hosoi, *Jap. J. Med. Sci. & Biol.* 7, 111 (1954); P. A. Woke, *Am. J. Hyg.* 25, 372 (1937).
2. D. W. Twohy and L. R. Rozeboom, *ibid.* 65, 316 (1957).
3. A. N. Clements, *J. Exptl. Biol.* 33, 211 (1956).
4. This work was supported in part by a grant from the National Institute of Allergy and Infectious Diseases, U.S. Department of Health, Education, and Welfare.
5. V. B. Wigglesworth, *The Physiology of Insect Metamorphosis* (Cambridge Univ. Press, New York, 1954).
6. T. S. Detinova, *Zool. Zhur.* 24, 291 (1945).
7. J. D. Gillette, *Nature* 180, 656 (1957).

19 November 1957

Testing a Servoanalytic Hypothesis for Pupil Oscillations

Oscillations are a common and important instance of the malfunctioning of a servomechanism. Oscillations are also a common pathological abnormality in a wide variety of neurological diseases and are manifested in such clinical signs as tremor, ataxia, clonus, and nystagmus. This report indicates how a biological system has been analyzed by linear servoanalytic methods and experimentally justifies this approach by quantitatively verifying a prediction.

The pupil response to light—an example of neurological servosystem—has been studied by means of servoanalytic concepts and techniques (*1*). A sinusoidally varying intensity of light was applied, and the pupil area was continuously recorded. When intensity increases, the pupil contracts. The resultant effect of light falling on the retina can be resolved into two factors: (i) an increase due to increase in applied intensity and (ii) a decrease due to contraction of the pupil. System gain is here defined as the ratio of (ii) to (i). An open-loop transfer function

$$G(s) = 0.16e^{-0.18s}/(1+0.1s)^3$$

was computed from data graphically displayed in Fig. 1. This, the Nyquist diagram, is a vector plot of the relationship between gain and phase shift at various frequencies. For example, at 1.2 cy/sec, the gain is 0.12, with a phase lag of 180°. This gain means that the pupil compensates for 12 percent of the change in applied light intensity.

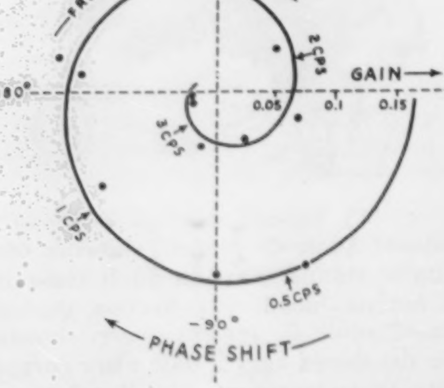

Fig. 1. Nyquist diagram of pupil response. This is a vector plot of gain and phase shift. The scale of the medulus is shown, and a few frequencies are indicated. The curve is derived from fitted lines from gain and phase frequency-response graphs, while the points are experimental.

If the gain were to be increased to 1.0 or more, the system would become unstable, and the pupil would oscillate at its natural frequency—that is, the frequency at which the phase lag is 180°. From the figure we see that this frequency is 1.2 cy/sec. Thus, from our servoanalysis of the normal, low-gain, stable pupil system, we are led to predict that a large increase in gain would produce sustained oscillations and that the frequency of these oscillations would be 1.2 cy/sec (72 cy/min). A test of the validity of the servoanalytic method would be the production of pupil oscillations in this manner and at the predicted frequency. Observations which comprise such a test are already available for evaluation.

Clinical studies have been reported in which sustained oscillations of the pupil have been produced and in which the frequency of the oscillations has been measured. Stern (*2*) pointed out that a series of oscillations of the pupil could be induced by imaging a small point of light just on the margin of the pupil. This causes the iris to contract, and all the light is cut off in the early phase of contraction. The iris therefore redilates, and full light intensity again enters the eye. The gain is thus increased to more than 1.0, and sustained oscillations result. Campbell and Whiteside (*3*) made a careful study of parameters affecting this induced pupil oscillation, using quantitative techniques on a group of normal subjects. A third report is that of Wybar (*4*), who studied a large number of normal subjects and also patients with multiple sclerosis (*5*). In Table 1 the frequencies of the sustained oscillation observed are summarized.

Table 1. Observed frequencies of pupil oscillations (references in parentheses).

Group studied	Mean frequency (cy/min)
10 Normal subjects (*2*)	80
1 Normal subject (*3*)	71
37 Normal subjects (*3*)	69
34 Normal subjects (*4*)	62
Patients with multiple sclerosis: 70 pupils (*4*)	41
Predicted value (*1*)	72

There is good agreement between the frequency of pupil oscillations observed in normal subjects and our prediction. Further experiments have been carried out by Stark and Baker (*6*) in which the transfer function of the pupil system has been altered by drugs. For example, when the 180°-phase cross-over frequency was changed from 1.5 to 0.9 cy/sec, the high-gain oscillation frequency shifted in a parallel fashion from 1.5 to 1.0 cy/sec (*6*).

The qualitative value of the servoanalytic approach is demonstrated by the clarification introduced through explanation of the nature of these pupil oscillations. The quantitative nature of the method is illustrated by the accuracy of the prediction (*7*).

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References and Notes

1. L. Stark and P. Sherman, *J. Neurophysiol.* 20, 17 (1957).
2. H. J. Stern, *Brit. J. Ophthalmol.* 28, 275 (1944).
3. F. W. Campbell and T. C. D. Whiteside, *ibid.* 34, 180 (1950).
4. K. C. Wybar, *Proc. Roy. Soc. Med.* 45, 315 (1952).
5. It is interesting to note that oscillation of the pupil in the multiple sclerosis group differs from that in the normal groups in mean frequency. This difference must be a result of a change in system parameters produced by the neurological lesions.
6. L. Stark and F. Baker, unpublished.
7. We gratefully acknowledge discussions with Peter Schultheiss, Philip Sherman, Fergus Campbell, and Gilbert Glaser. This work is being supported by the National Multiple Sclerosis Society, the National Science Foundation, the National Institute of Neurological Diseases and Blindness, and the George Knight Fund.

4 November 1957

Preparation of an Apoprotein from Ceruloplasmin by Reversible Dissociation of Copper

The blue copper-protein of plasma, ceruloplasmin, with a molecular weight of 151,000, contains eight atoms of copper per molecule (*1*). The physiologic significance of this protein, while not clear, has usually been implicitly associated with its oxidase activity (*2–5*). On the other hand, the possibility that reversible binding and release of copper by the protein may be the basis of its physiologic role has been considered improbable (4), largely because attempts at removing the copper from the protein have resulted in irreversible denaturation of the ceruloplasmin (2, 6). A consideration of the possible etiologic relationship of hereditary deficiency of ceruloplasmin to Wilson's disease, which is primarily a disorder of copper metabolism, led to experiments with radioactive copper and ceruloplasmin which indicated that the copper-protein bond can, in fact, be reversibly dissociated under certain conditions (7). These results suggested that it might prove possible to remove copper from ceruloplasmin and prepare an apoprotein which would be capable of recombining with copper to form ceruloplasmin. This report describes experiments in which such an apoprotein was obtained (8).

The reversible separation of the copper and protein was effected under conditions which were as similar as possible to those under which exchange of ceruloplasmin copper and radioactively labeled copper ions had been observed. The procedure was carried out, therefore, in an acetate buffer and in the presence of sufficient ascorbic acid to keep the ceruloplasmin copper in the monovalent state throughout its removal from the protein. Advantage was taken of the fact that the diethyldithiocarbamate ion combines tightly with copper ions to form a colloidal suspension (9). This made it possible to remove by ultracentrifugation the copper which had been separated from ceruloplasmin.

Solution A (Table 1) was made by bringing ceruloplasmin preparation AK-81 (10) to a *p*H of 5.2 and an ionic strength of 1.2 with acetate buffer. To 35.5 ml of solution A, which contained 8.5 mg of ceruloplasmin per milliliter, 58.5 mg of crystalline ascorbic acid was added, which instantly decolorized the blue solution. During the next 5 hours the solution was kept at 0°C and was stirred while 9.3 ml of 0.4-percent sodium diethyldithiocarbamate in water was added, dropwise. The final mixture, B—golden brown and slightly cloudy—was centrifuged in a Spinco model L ultracentrifuge for three hours at 40,000 rev/min, at 0°C. The black precipitate was analyzed quantitatively for copper, and 32.0 ml of slightly yellow, but clear, supernatant solution, C-1, was passed at 0°C through a column of ion-exchange resins containing 10 ml of IR-120 (sodium) resin and 15 ml of IRA-400 (acetate) resin (11). By rejecting the dilute fore- and after-runs, we obtained 31.0 ml of a clear, water-white solution, C-3, which contained 69.9 percent of the protein of solution A. The C-3 solution, which contained the apoprotein, was kept frozen at -30°C in several aliquots. Ceruloplasmin was regenerated after thawing by the addition of 1.3 ml of ascorbic acid solution (120 μg/ml), 3.0 ml of cupric sulfate solution (20 μg of Cu^{++} per milliliter), and 7.7 ml of water to 3.0 ml of C-3. After passage of this solution through a column which contained 7 ml of acetate resin and 14 ml of sodium resin (12), and which had been previously equilibrated with a 0.2*M* acetate buffer of *p*H 5.25, 14.8 ml of a clear blue solution, C-4, which contained ceruloplasmin, was collected.

Table 1 lists comparative analytical data on the original ceruloplasmin, the apoprotein, and the regenerated ceruloplasmin. It is clear that about 95 percent of the blue color, enzymatic activity, and ceruloplasmin copper possessed by the protein in solution A have been removed from C-3.

The analyses of C-4 indicate that nearly 60 percent of both the blue color and tightly bound ceruloplasmin copper and 86 percent of the enzymatic activity present in solution A were restored to C-3. Addition of up to ten times as much copper and ascorbic acid as were used originally resulted in no greater intensity of blue color or greater yield of tightly bound copper or enzymatic activity.

We have observed that the addition of cupric ions without ascorbic acid to a solution of apoprotein does not result in the formation of blue ceruloplasmin. However, enzymatic activity equal to that of C-4 is found in this solution if the substrate paraphenylenediamine dihydrochloride is added after addition of the cupric ions. Oxidation of this substrate produces dark-colored products which have prevented us from determining if the paraphenylenediamine dihydrochloride has restored blue color to the apoprotein-cupric ion mixture in addition to restoring enzymatic activity.

The percentage of enzymatic activity restored to C-4 is disproportionately higher than the amounts of blue color and tightly bound copper which were regenerated. It has consistently been found to be the case that each atom of copper which is recombined with apoprotein is about 1.5 times as active enzymatically as an atom of copper in the original ceruloplasmin. Yet this enhancement is not found with respect to the blue color. Current work is directed toward determining the reason for this discrepancy.

The physiologic significance of the demonstration that ceruloplasmin can exist as an apoprotein remains to be clarified. It is at least consistent with the hypothesis that ceruloplasmin functions by reversibly releasing and binding copper at various sites in the organism, possibly thereby regulating the absorption

Table 1. Quantitative comparison of some characteristics of ceruloplasmin (solution A), the apoprotein (solution C-3), and regenerated ceruloplasmin (solution C-4). (O.D., optical density.)

Characteristic	Solution		
	A	C-3	C-4
Total protein			
$\text{O.D.}_{1\text{ cm}}^{280\text{ m}\mu}$	15.25	10.64	2.00
Nitrogen (mg/ml)	1.4	1.09	0.195
Blue color			
$\Delta\,\text{O.D.}_{1\text{ cm}}^{610\text{ m}\mu}$ *	0.635	0.011	0.048
Blue color, as percentage of that in solution A, corrected for content of total protein†	100	2.48	57.5
Copper			
Total (μg/ml)‡	30.7	1.46	2.54
Free (μg/ml)§	1.7	0.00	0.32
Ceruloplasmin copper (μg/ml)‖	29.0	< 1.46	2.22
Ceruloplasmin copper, as percentage of that in solution A, corrected for content of total protein†	100	< 7.2	58.4
Enzymatic activity			
$\Delta\,\text{O.D.}_{1\text{ cm}}^{530\text{ m}\mu}$/min ml¶	0.832	0.0334	0.0935
Enzymatic activity, as percentage of that in solution A, corrected for content of total protein†	100	5.7	86.0

* Difference in O.D. before and after decolorization of ceruloplasmin by ascorbic acid. All $\Delta\text{O.D.'s}_{1\text{ cm}}^{610\text{ m}\mu}$ were higher than ΔO.D.'s at other wavelengths between 540 and 660 mμ (see 7).

† The calculation for blue color is as follows:

$$(\Delta\text{O.D.}_{1\text{ cm}}^{610\text{ m}\mu}/\text{O.D.}_{1\text{ cm}}^{280\text{ m}\mu}) \times [(\text{O.D.}_{1\text{ cm}}^{280\text{ m}\mu}/\Delta\text{O.D.}_{1\text{ cm}}^{610\text{ m}\mu})]_{\text{soln A}} \times 100.$$

Percentages of ceruloplasmin copper and of enzymatic activity are calculated in an analogous manner.

‡ By wet digestion (see 7). Of the 1090 μg of copper in solution A, 983 μg were found, by analysis, in the precipitate and supernatant (C-1) from the ultracentrifugation. Of the copper accounted for, 914 μg, or 93 percent, was in the precipitate.

§ Copper which will react directly with dicyclohexanoneoxalyldihydrazone to form a blue compound at *p*H 7 (see 7).

‖ Total minus free. The amount of ceruloplasmin copper in solution C-3 has not been determined with certainty, but it is less than 1.46 μg/ml, since any copper-diethyldithiocarbamate which is present in solution will not react with dicyclohexanoneoxalyldihydrazone.

¶ Measured spectrophotometrically by effect on rate of oxidation of paraphenylenediamine (see 7).

of copper. Indirect evidence for this theory may be present in the relationship of hereditary deficiency or absence of ceruloplasmin to hepatolenticular degeneration (Wilson's disease), as has been previously outlined (7), but proof of this concept is still to be obtained.

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References and Notes

1. C. G. Holmberg and C.-B. Laurell, *Acta Chem. Scand.* 2, 550 (1948).
2. ———, *ibid.* 5, 476 (1951).
3. ———, *Scand. J. Clin. & Lab. Invest.* 3, 103 (1951).
4. C. J. Gubler *et al., J. Clin. Invest.* 32, 405 (1953).
5. S. J. Adelstein, T. L. Coombs, B. L. Vallee, *New Engl. J. Med.* 255, 105 (1956); B. E. Leach *et al., A.M.A. Arch. Neurol. Psychiat.* 76, 635 (1956); S. Akerfeldt, *Science* 125, 117 (1957).
6. H. Bickel *et al., Klin. Wochschr.* 34, 961 (1956).
7. I. H. Scheinberg and A. G. Morell, *J. Clin. Invest.* 36, 1193 (1957).
8. This work was supported in part by a grant (A-1059) from the National Institute of Arthritis and Metabolic Diseases of the National Institutes of Health, United States Public Health Service, and by a grant [NONR-1765 (00)] from the Office of Naval Research. We are grateful to Miss Gwendolyn Stevens for valuable technical assistance.
9. R. E. Peterson and M. E. Bollier, *Anal. Chem.* 27, 1195 (1955).
10. Fraction IV from human plasma was obtained through the kind cooperation of James A. McComb (director), John M. Newell, and Lewis H. Larsen, of the Massachusetts Public Health Biologic Laboratories, and of Sam T. Gibson, director, American National Red Cross Blood Program. Ceruloplasmin AK-81 was prepared from fraction IV and was generously supplied to us by H. O. Singher and Alan Keltz of the Ortho Research Foundation, Raritan, N.J.
11. The primary aim in using ion-exchange resins in this procedure was to remove the excess ascorbic acid present in C-1 by anion exchange. However, for reasons that are not known, an apoprotein solution capable of being converted into blue ceruloplasmin was never obtained unless C-1 was also passed over a cation-exchange resin.
12. IR-120 and IRA-400 resins were used here both to remove excess copper and to demonstrate that the copper of the regenerated ceruloplasmin, like that of the original material, cannot be removed by a cation exchange resin.

4 October 1957

Severe Arteriosclerosis and Other Diseases in the Rat Produced by Corticotrophin

In older rats repeatedly injected with corticotrophin (ACTH), we have observed several disease syndromes: in the female, extremely severe arteriosclerosis; in the male, polyarteritis nodosa, gastric ulcers, testicular atrophy, and renal calculi, but no arteriosclerosis. Both sexes developed a marked hypertension (only systolic pressures were measured).

Male and female Sprague-Dawley rats, approximately 1 year old, were injected with ACTH subcutaneously three times a week for periods of up to 7 weeks. The dose was 0.333 of a unit per 100 g of body weight. The animals were maintained on a standard rat diet without fat supplements or any added salt in the drinking water. Some groups of rats were unilaterally nephrectomized. The older animals were all discard breeders. Equivalent groups of male and female weanling rats were treated identically.

Female rats. After administration of ACTH, a fulminating type of arteriosclerosis, involving the entire aortic tree, was observed in the female rats (Fig. 1). The large arteries showed a senile type of ectasia, in which the aorta was so severely stiffened that it could be made to stand by itself when dissected free of its bed. The arteriosclerotic changes extended into the cerebral vessels, the peripheral vessels, and the coronary arteries. In the more severe cases, saccular aneurysms were encountered in the arch of the aorta.

Microscopic examination demonstrated that several types of arterial damage were proceeding simultaneously in various segments of the aorta. Many areas were characterized by intimal swelling and proliferation, accompanied by medial hypertrophy and alteration of the elastic tissues. In some areas of intimal proliferation, the adjacent media showed necrosis and calcification, and in others, calcification was of the metastatic variety, without prior necrosis. Cartilaginous metaplasia with formation of bars of cartilage were frequently seen in the same animals. The aneurysms occurred in areas where the elastic tissue had become swollen and fragmented, permitting herniation of the arterial wall. The intimal plaques contained minute droplets of intracellular, and some extracellular, fat. Histochemical stains revealed profound changes in the mucopolysaccharides, or ground substance, of all layers of the arterial wall. The elastic fibers were disrupted, particularly above the intimal vegetations, and the normally regular elastic lamellae were stretched and distorted. Under tension, the interlamellar elastic fibrils were accentuated.

In some vessels, including the coronary arteries, thromboses were encountered, along with subsequent recanalization.

The coronary vessels stood out in abnormally sharp relief against the myocardium. The arteries were kinked and stiffened and showed intimal calcification, medial swelling, and fragmentation of the elastic tissue. Multiple infarcts were found in the ventricular portions of the heart. The cerebral vessels showed swollen tunica media, derangement of elastic tissue, and intimal calcification.

Male rats. Entirely different lesions were encountered in the males. In approximately 30 percent of these animals we observed polyarteritis nodosa, with severe aneurysmal dilatation, especially in the mesenteric arteries. Deep, penetrating gastric ulcers developed in more than half of the animals, usually two large ulcers and several smaller ones.

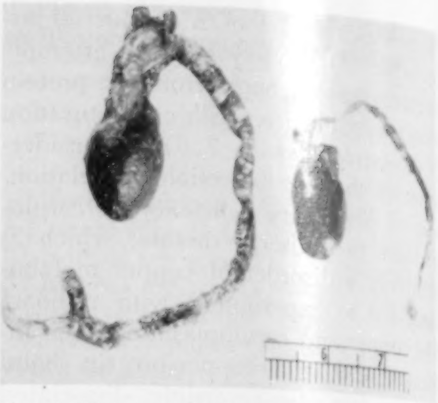

Fig. 1. Heart and aorta of ACTH-treated (left) and control (right) 1-year-old female rats. The ACTH-treated rat shows cardiac hypertrophy, ectasia, small saccular aneurysms, and silvery-white placodes throughout.

Testicular atrophy, too, occurred very frequently. In 85 percent of the animals the testes were unusually hard and firm and showed snow-white areas suggestive of fibrosis. The tubules appeared to be contracted. These tissues are now being studied microscopically.

Multiple renal calculi were encountered in about one-third of the animals. The lithiasis was intense; as many as 70 hard stones were found in one kidney. Chemical analyses of these stones are being made, and the problem of abnormal calcium metabolism in the animals is being studied.

The high incidence of polyarteritis, gastric ulceration, and testicular fibrosis can be ascribed to the administration of the ACTH. We are not yet certain whether this is equally true of the renal lithiasis, for kidney stones have also been found in some of the control male rats. This problem is being studied further.

In the older male and female rats another finding of interest is that of unusually rapid aging, evidenced by the lethargic behavior of the animals and the worn condition of their coats.

In contrast, the young, weanling rats, male and female, showed remarkably little gross pathology. Microscopic sections from these animals are now being studied.

Discussion. Experimental production of arteriosclerosis has, up to the present time, been restricted almost entirely to the rabbit and chicken (*1*). Our studies (*2*) suggest that a more suitable animal, the rat, can be employed. Further experiments will be required to determine whether the female rat is susceptible only under the special conditions we have employed—that is, whether only the discard breeders are susceptible (*3*). If this is the case it focuses attention on the stress of repeated pregnancy in these animals as a sensitizing factor in the subsequent development of arteriosclerosis. Preliminary experiments we have performed on the effect of exposure to cold and heat suggest that stressful situations other than exogenous administration of ACTH will also induce arteriosclerosis in these discard breeders.

Although unilateral nephrectomy is not essential to the production of arteriosclerosis, it does appear to intensify the lesions. However, the age of the rats is clearly a critical factor. Experiments are in progress to ascertain the youngest age at which rat arteriosclerosis can be initiated by ACTH injections. In addition, the effects of smaller amounts of ACTH and of less frequent injections are being studied in an effort to detect the earliest lesions of arteriosclerosis.

Because so much attention has been centered on the role of fat in the genesis of human arteriosclerosis, it should be emphasized that our rats were fed a normal diet not supplemented with fats. Furthermore, the serum cholesterol levels of our animals did not rise during the development of vascular disease. This does not, however, exclude the possibility that fat metabolism in the arterial wall itself is altered, and that this alteration is responsible for the changes observed in the rats.

The characteristic lesions observed in male rats may also provide some interesting experimental tools. The deep, penetrating peptic ulcers and the multiple renal calculi produced by ACTH administration may prove to be extremely useful in the study of peptic ulcer and kidney stones in man. The apparent speeding up of the aging process, observed in both male and female rats, also suggests research applications.

It is of interest to note that the dosage of ACTH we have administered (0.333 of a unit per 100 g body weight) is the equivalent of approximately 200 units in an average-sized human being. This is close enough to therapeutic levels to make one question the possible toxic effects of ACTH on the human vascular system in susceptible patients. Indeed, when one surveys the spectrum of lesions obtained in both male and female rats—arteriosclerosis, hypertension, senescent changes, renal stones, and gastric ulcerations—it is tempting to compare these changes with those seen in Cushing's disease. The possibility that the severe arteriosclerosis observed in our rats may actually result from hyperfunctioning of the adrenal glands is suggested by the fact that we have found these glands to be enlarged and the thymus glands to be involuted.

If further experiments prove that the arteriosclerotic lesions in the rat closely resemble those in human beings, the effects of an overactive pituitary-adrenal axis on arteriosclerosis in man will demand evaluation. If, as Selye believes, the stresses of life are channeled through the pituitary-adrenal system (*4*), stress may conceivably be an important determinant in human arteriosclerosis.

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References and Notes

1. I. H. Page and H. B. Brown, *Circulation* **6**, 681 (1952).
2. These studies were aided by a grant from the John A. Hartford Foundation and by grant No. H2730 from the U.S. Public Health Service.
3. D. J. Ingle and B. L. Baker, *Recent Progr. in Hormone Research* **8**, 143 (1953).
4. H. Selye, *Stress* (Acta, Montreal, Canada, 1952).

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25 November 1957

Use of Arginine to Eliminate Medium Changes in Tissue Culture Systems

Conventional tissue-culture techniques require that the nutrient medium be changed at frequent intervals. This methodology presents no difficulty in the instance of the small volumes handled in flask or test-tube type cultures. On the other hand, it presents a major obstacle to successful and continuous cultivation of mammalian cells in fluid agitated suspension (submerged culture), in volumes of 3 to 20 liters, as commonly employed in our laboratories (*1–3*). This report presents the results obtained when L-arginine is employed as a means of circumventing the necessity for making frequent changes of medium in such submerged culture systems. This is important not only from the standpoint of economy or ease of manipulation but also in relation to certain types of biochemical and biological experiments wherein it is desirable to maintain, as closely as possible, a somewhat constant cellular environment.

On the basis of the studies of Westfall *et al.* (*4*) it was known that, in certain tissue culture systems, histidine, arginine, isoleucine, methionine, and phenylalanine were rapidly depleted. It occurred to us that these substrates might be limiting and, as such, might be used to maintain active rates of cellular proliferation without renewal of media. Subsequent experiments (*5*) have demonstrated the validity of this assumption and, further, the fact that use of arginine alone is sufficient for this purpose.

In the basic investigations, Earle's L cell was used in Spinner culture (*1*). The nutrient medium routinely used was a modified Eagle's mixture (*3*). Rates of cellular proliferation were appraised by direct enumeration in a hemocytometer. Cell viability was determined through use of the vital stain trypan blue (*1*).

Submerged-culture cells of the L strain procured from a New Brunswick fermentor were centrifuged and resuspended in equal volumes of nutrient media in three Spinner vessels. Thereafter, the three Spinner cultures received additions of substrate every other day as follows: the control culture received saline; the second vessel received 21 μg of L-arginine per milliliter of culture; 42 μg of L-arginine per milliliter was introduced into the third vessel.

In this typical experiment there were uniform rates of cellular proliferation in all three Spinners during the first 2 days after initiation of the test (Fig. 1). After the 4th day, the cell concentration of the control culture decreased rapidly; this was followed by a loss in cell viability of from 98 percent on the 6th day to 30 percent by the 11th day.

Cells in the Spinner vessel that had received 21 μg of arginine per milliliter of culture continued to proliferate until the 4th or 5th day, when stabilization of the cell population occurred; this was followed by a gradual drop in cell concentration. The cell viability of this culture was maintained at a level above 90 percent through the 11th day. Active cellular proliferation in the 42 μg/ml culture was maintained, in this experiment, until the 8th or 9th day. Viability of this culture was maintained at a level above 95 percent throughout the 11th day (Fig. 1).

Addition of concentrations of 84 to

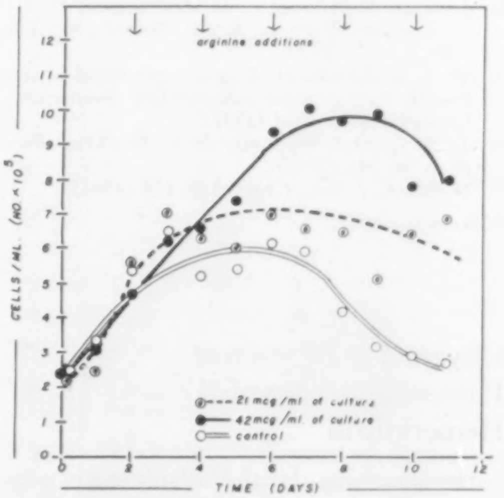

Fig. 1. The effect of arginine on the proliferation of L cells in submerged culture.

336 μg of arginine per milliliter of culture has resulted in greater early stimulation of cellular proliferation, although the final cell populations did not approach that achieved with the 42 μg/ml level. No manifestations of toxicity were apparent at the higher concentrations.

Addition of arginine has been found to be useful for the maintenance of strain HeLa or Westwood's ERK/KD cell line (*6*). In addition, arginine has been used effectively as a supplement in a serum-free medium employed for maintenance of the ERK/KD cells in submerged culture (20-liter) during the experimental production of viral antigens (*7*). In some instances, active cellular proliferation has been maintained for periods up to 20 days through the addition of arginine and new media.

Several possibilities relating to the mechanisms of this action of arginine may be mentioned, such as one similar to the mechanism described for the protection, by arginine, of rats against ammonia toxicity (*8*). Again, arginine may be incorporated directly into tissue protein, as was demonstrated by Bloch (*9*). We have found that citrulline (but not ornithine) will operate in the same fashion and to the same degree of efficacy as arginine in cultures of L cells. The mechanism of action of arginine in cultures of mammalian cells has not been determined as yet, and further comment on the subject must await more detailed studies.

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References and Notes

1. W. F. McLimans *et al.*, *J. Immunol.* 79 (1957).
2. W. F. McLimans *et al.*, *J. Bacteriol.*, in press.
3. D. W. Ziegler *et al.*, *Appl. Microbiol.*, in press.
4. B. B. Westfall, E. V. Peppers, W. R. Earle, *Am. J. Hyg.* 61, 326 (1955).
5. This study was supported by a grant from the U.S. Army Chemical Corps, Fort Detrick, Frederick, Maryland (contract No. DA-18-064-404-CML-74).
6. J. C. N. Westwood, I. A. MacPherson, D. H. J. Titmuss, *Brit. J. Exptl. Pathol.* 38, 138 (1957).
7. W. F. McLimans *et al.*, paper presented at the Fourth International Poliomyelitis Conference, Geneva, Switzerland (1957).
8. J. P. Greenstein *et al.*, *Arch. Biochem. Biophys.* 64, 342 (1956).
9. K. Bloch, *J. Biol. Chem.* 165, 469 (1946).

9 December 1957

Oxygen Equilibrium of Phascolosoma agassizii Hemerythrin

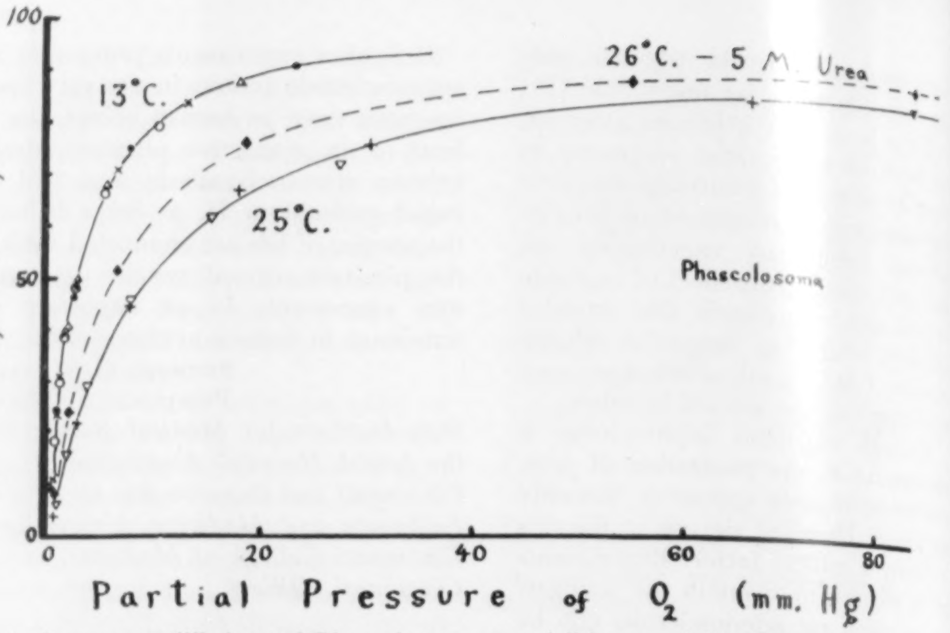

Fig. 1. Oxygen equilibrium of *Phascolosoma agassizii* hemerythrin. Two percent hemerythrin in potassium phosphate buffer, $\Gamma/2 = 0.2$. Solid lines: no urea present; experiments at 13°C performed at *p*H's of 7.90, 7.23, 6.79, and 5.75; experiments at 25°C performed at *p*H's of 7.74 and 7.27. Dashed line: 5*M* urea present; experiment performed at 26°C and a *p*H of 8.08.

Hemerythrin is the respiratory pigment of the phylum Sipunculida, whose members are small-to-medium-sized worms frequently found buried in an oxygen-deficient substratum. Hemerythrin is reddish-purple when oxygenated, colorless when deoxygenated; this is in contrast to the other two iron-containing respiratory pigments, hemoglobin and chlorocruorin. Hemocyanin, the oxygen-binding copper protein of arthropods and molluscs, resembles hemerythrin in being colorless when deoxygenated. On the basis of chemical and thermodynamic evidence, Klotz and Klotz (*1*) have concluded that oxygenation of hemerythrin and hemocyanin differs from that of heme respiratory pigments in that the metal undergoes a valence change upon the reversible combination with O_2. Klotz and Klotz have reported that the heat of oxygenation of *Golfingia* [formerly *Phascolosoma* (*2*)] *gouldii* is about twice that of hemoglobin and have utilized this fact as evidence for the acceptance of two electrons by the oxygen molecule in oxyhemerythrin—in contrast to oxyhemoglobin, where the ligand does not gain electrons.

However, two other workers have observed that the effect of temperature on the oxygen equilibrium of the hemerythrin of *Sipunculus nudus* (*3*) and of a species of *Golfingia* (*4*) was very similar to its effect on the oxygen-hemoglobin equilibrium. This, coupled with the small amount of published information on the oxygen-hemerythrin equilibrium, has warranted a study of the hemerythrin of the "peanut worm," *Phascolosoma* (*Physcosoma*) *agassizii* Keferstein (*5*).

Hemerythrin was prepared by distilled water hemolysis of clotted coelomic cells, followed by centrifugation and filtration. Forty specimens of this small sipunculid yield approximately 1 ml of a 3 percent hemerythrin solution. Oxygen dissociation curves were determined by spectrophotometric analysis ($\lambda = 580$ to 600 mμ) of the mixture of "reduced" and oxygenated hemerythrin formed upon equilibration with known partial pressures of oxygen. The partial pressure of oxygen was varied by injection of known quantities of air into a confined space with the respiratory pigment, as in the technique of Riggs (*6*).

The result of experiments on the effect of *p*H, temperature, and urea on the oxygen-hemerythrin equilibrium is shown in Fig. 1. Since the position of the oxygen dissociation curve is invariant to *p*H change, this particular hemerythrin lacks a Bohr effect, as do other sipunculid hemerythrins (*3, 4*). Although a slightly sigmoid oxygen dissociation curve has been observed for *Sipunculus* hemerythrin (*3*), *Phascolosoma agassizii* hemerythrin possesses a hyperbolic curve.

From the data (Fig. 1) on *Phascolosoma agassizii* hemerythrin at two different temperatures, it is possible to calculate (*7*) a heat of oxygenation (ΔH°) in terms of a standard state of 1-atm pressure of dissolved oxygen gas; the following integrated form of the van't Hoff equation was used:

$$\ln\left[\frac{p_{50}(T_1)}{p_{50}(T_2)}\right] = \frac{\Delta H^\circ}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right],$$

where $p_{50}(T)$ represents the partial pressure of O_2 (in atmospheres) at which, at the specified temperature, there is exactly 50 percent of the respiratory pigment in an oxygenated condition. When the oxygen dissociation curve is hyperbolic, the equilibrium constant is the reciprocal of $p_{50}(T)$. For this particular hemerythrin, a value of $\Delta H^\circ = -17$ kcal was observed; this is closer to the recently observed value of –18 kcal for *Golfingia gouldii* hemerythrin (*2*) than to corresponding values of earlier workers (*3, 4*), which are approximately –10 kcal. The most recently observed values for hemoglobin are significantly lower: –8.2 kcal for sheep hemoglobin (*8*) and –8.4 kcal for *Cucumaria miniata* hemoglobin (*9*). Preliminary experiments with the coelomic hemerythrin of *Dendrostomum zostericolum* indicate that the heat of oxygenation is –20 kcal. Hence, this aspect of the trend in values of ΔH° predicted by Klotz and Klotz (*2*) has been confirmed.

Also in terms of a standard state of 1 atm of dissolved oxygen gas, an entropy of oxygenation can be calculated (*7*) from the relations:

$$\Delta F^\circ = -RT \ln K = RT \ln p_{50}$$

and

$$\Delta S^\circ = -\frac{\partial(\Delta F^\circ)}{\partial T}$$

For *Phascolosoma agassizii* hemerythrin $\Delta S^\circ = -46$ cal/deg, as compared with values approximating –10 to –15 cal/deg for various hemoglobins (*10, 11*). For hemoglobin these negative entropies, together with other biochemical evidence have been interpreted (*11, 12*) as indicating that, upon oxygenation of "reduced" hemoglobin, a definite configurational change in the protein moiety occurs, oxyhemoglobin being the more "ordered" form of the protein. Such an explanation would be plausible for hemerythrin, particularly in that such an entropy change during oxygenation cannot represent changes in the state of aggregation of solvent molecules about proton-affine centers in the protein moiety —for hemerythrin lacks a Bohr effect. That the oxygen equilibrium of hemerythrin as with hemoglobin (*11*) depends on the configuration of the protein moiety is also shown by the increase in oxygen affinity upon addition of urea (Fig. 1).

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References and Notes

1. I. M. Klotz and T. A. Klotz, *Science* **121**, 1 (1955).
2. Scientific names of sipunculids in this paper are given in accordance with the revision in nomenclature proposed by W. K. Fisher, *Proc. U.S. Natl. Museum* **102**, 371 (1952).
3. M. Florkin, *Arch. intern. physiol.* **36**, 247 (1933).
4. G. F. Marrian, *Brit. J. Exptl. Biol.* **4**, 357 (1927).
5. I acknowledge the assistance of J. P. Baumberger, A. C. Giese, and S. Gross, for helpful discussion and provision of material. This research was done on tenure of a National Science Foundation fellowship.
6. A. Riggs, *J. Gen. Physiol.* **35**, 23 (1951).
7. S. Glasstone, *Thermodynamics for Chemists* (Van Nostrand, New York, 1947). Such a heat of oxygenation includes a heat of ionization of proton-affine centers on the protein moiety and of surrounding buffer ions only when there is a Bohr effect—that is, interaction between oxygen-affine and proton-affine centers.
8. W. Paul and F. J. W. Roughton, *J. Physiol. (London)* **113**, 23 (1951).
9. C. Manwell, unpublished. With reference to Paul and Roughton (*8*), *Cucumaria miniata* hemoglobin lacks a Bohr effect (*p*H 6 to 8), as does sheep hemoglobin at sufficiently alkaline *p*H.
10. D. D. Eley, *Trans. Faraday Soc.* **39**, 172 (1943).
11. J. Wyman and D. W. Allen, *J. Polymer Sci.* **7**, 499 (1951).
12. A. F. Riggs and R. A. Wolbach, *J. Gen. Physiol.* **39**, 585 (1956).

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Separation of Human Plasma Protein Concentrate with Insulin Activity

Insulinlike activity of human plasma has been identified in plasma fraction II + III as obtained by the cold-ethanol method and in plasma globulin precipitate obtained by equilibrating plasma with 50 m*M* zinc (**1**). Identical fractions prepared from resin-collected plasma were inactive. The suggestion that cationic exchange resins (Dowex-50, IRC-50) employed for blood collection remove the insulin activity was verified when an attempt was made to elute the insulinlike activity from resins. In these experiments it was calculated that 40 percent of the total plasma activity was recovered from the cationic exchange resins with 0.3*M* citric acid, at *p*H 3.0 (*2*).

The percentage of recovery has been increased by treating the resins after blood collection with 1 resin volume of 0.2*M* citric acid at 2°C for 72 hours (*3*). The resins were washed two times, before elution, with cold distilled water to remove the red blood cells and the contaminating proteins and, finally, were washed once with 0.15*M* sodium chloride. After dialysis of the eluate for 36 hours against four to five volumes of distilled water at 2°C, the solution was dried from the frozen state, and the residue was dissolved in the smallest possible volume of cold water. Dialysis followed, for 48 hours, against 0.15*M* sodium chloride at 2°C.

Biological tests for insulin activity of the resin eluates were performed by using, respectively, hypophysectomized-alloxanized rats (*4*); epididymal fat tissue (*5*); and rat diaphragm (*6*). The recovery of the original plasma insulin activity from the resin was indicated variously at from 40 to 80 percent by the above methods.

Eluates from resins representing the collection of 30 to 40 lit of human plasma were pooled, and the volume was reduced to 2 ml. Paper electrophoresis was performed on the Spinco model R, series D, paper electrophoresis cell, at 2.5 ma for 18 hours, with Veronal buffer, *p*H 8.6, ionic strength 0.1, and S and S 2043A-mgl paper strips, 3.0 by 30.6 cm. Insulin solution (0.018 ml) was applied on the paper. A plasma control was run at the same time by applying 0.006 ml of plasma. The paper electrophoresis indicated the presence in the eluate of an α_1-globulin and a γ-globulin when compared with the plasma control (Fig. 1). A portion of the protein in the γ-globulin area may be denatured protein, as might be expected from acid treatment for 72 hours.

In another study, 0.2 ml of the insulin solution was applied on a 4 by 31 cm paper strip (S and S 470); this was run at 40 ma for 16 hours at 2°C, with a phosphate buffer, *p*H 7.6, ionic strength 0.1. A plasma control was also run in the same machine. The control strip carrying the plasma was then developed, and the paper strip carrying the insulin solution was cut in five sections: the albumin, the α_1-globulin, the α_2-globulin, the β-globulins, and the γ-globulin. Elution followed, with 0.15*M* sodium chloride, and the eluates were tested for insulin activity (*5*). The α_1-globulin and the albumin section possessed in-insulin activity. The rest of the eluates were found to be inactive. The activity present in the albumin section may be due to the presence of some α_1-globulin, which is difficult to separate from albumin. There was a strong suggestion from the bioassay that the γ-globulin section had an inhibitory effect. The protein concentration of the final insulin concentrate was more than 1.5 million times that of the plasma.

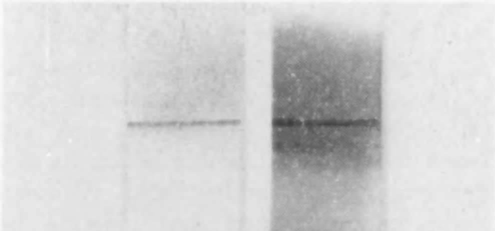

Fig. 1. Paper electrophoresis of the insulin concentrate (left) and plasma control (right). The protein concentration of the insulin concentrate is more than 1.5 million times that of the original plasma.

It is quite possible that the α_1-globulin, possessing the insulinlike activity, circulates in the blood stream in a complex form with another protein of higher molecular weight and isoelectric point, and that the whole complex is absorbed on the exchange resins. The treatment with 0.2*M* citric acid for 72 hours probably dissociates the insulin from the complex, the insulin appearing as an α_1-globulin by paper electrophoresis. This suggestion is supported by the observation that crystalline insulin in saline or in 3-percent human albumin solution treated with cationic exchange resins retains full activity (*2*).

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References and Notes

1. P. M. Beigelman *et al.*, *Metabolism Clin. and Exptl.* 5, 44 (1956).
2. H. N. Antoniades *et al.*, *ibid.*, in press.
3. This work has been supported by gifts from the Kresge Foundation, from the King Foundation, and from industry.
4. P. M. Beigelman *et al.*, *Metabolism Clin. and Exptl.* 5, 35 (1956).
5. Biological assays were kindly performed by Drs. D. Martin and A. E. Renold (New England Deaconess Hospital, Boston, Mass.).
6. Biological assays were kindly performed by Dr. K. Gunderson (University of Pennsylvania, Medical School, Philadelphia).

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Evidence for the Metabolism of Maleic Acid in Dogs and Human Beings

In 1951, Sacks and Jensen (*1*) presented evidence for the existence in maize kernels of a hydrase, malease, for the conversion of maleic acid to malic acid. More recently, Vickery and Palmer (*2*) reported that the general respiration of tobacco leaves was stimulated about 60 percent when the leaves were cultured in either fumaric acid or its geometrical isomer, maleic acid. Although their data suggested that maleate behaved as an inhibitor of the activity of the proteolytic enzymes and of the enzyme systems involved in the formation of citric acid, they noted that maleic acid entered extensively into reactions which involved decarboxylation.

Table 1. Arterial carbon dioxide activity following intravenous injection of maleate-2-C^{14} into a dog. "Specific activity" is expressed as the percentage of injected C^{14} per milligram of CO_2 carbon.

Time (min. after injection)	Total activity (count/min per 5 ml of blood)	"Specific activity"
5	781	0.000985
10	1042	0.001310
15	1270	0.001604
20	1373	0.001733
25	1525	0.001932
30	1632	0.002066

We have now obtained evidence of the presence in dogs and human beings of enzyme systems capable of oxidizing maleate-2-C^{14} to $C^{14}O_2$ (*3*). Following the injection of 45 μc (5.9 mg) of maleic-2-C^{14} acid into a 9.5-kg dog, arterial (femoral) blood specimens were collected in oiled, heparinized syringes at various time intervals (*4*). Carbon dioxide was liberated from 5 ml samples and collected as barium carbonate, and its activity was determined as previously described (*5*). The results (Table 1) show the increase with time of total carbon dioxide activity (per 5 ml of whole blood) as well as of "specific activity" of carbon dioxide. "Specific activity" is expressed as the percentage of injected carbon-14 per milligram of CO_2 carbon.

In Table 2 are given results that followed the intravenous injection of 90 μc (11.8 mg) of maleic-2-C^{14} acid into a normal human subject. For purposes of comparison, data are also given for a similar experiment in which fumaric-2-C^{14} acid (90 μc) was the injected substrate. These data show that $C^{14}O_2$ was formed readily in both cases; however, corresponding total activity and "specific activity" values were much higher in the fumarate-2-C^{14} experiment, indicating a faster reaction rate with that isomer. In the maleate experiment, the "specific activity" reached a maximum in about 70 minutes and had not declined at 90 minutes, whereas, in the fumarate experiment, the maximum was attained much sooner (in about 40 minutes) and then carbon dioxide "specific activity" declined.

As one test of the possible conversion of maleates to fumarate within the body, copper pyridyl fumarate salts (*5*) were made from the blood filtrates and assayed for carbon-14 activity. Whereas, in the maleic acid experiments, very little activity was found in the copper pyridyl fumarate salts (59 count/min per 5 ml of arterial blood after 23 minutes), in the fumarate-2-C^{14} experiments, considerably more activity was found (1068 count/min per 5 ml of arterial blood after 20 minutes), and this activity was evident even 70 minutes following intravenous injection into a human being (see *5*, Table 2). This evidence does not rule out completely the possibility that there is a conversion of maleate to fumarate within some body tissues, with a subsequent rapid oxidation to carbon dioxide and with no entrance of fumarate into the blood stream; however, it does suggest the improbability of such a hypothesis.

Table 2. Arterial carbon dioxide activity following intravenous injection of (i) maleate-2-C^{14} or of (ii) fumarate-2-C^{14} into normal human subjects. "Specific activity" is expressed as the percentage of injected C^{14} per milligram of CO_2 carbon.

Time (min. after injection)	Total activity (count/min per 5 ml of blood)	"Specific activity"
	Maleate-2-C^{14}	
5	159	0.000135
10	277	0.000229
20	355	0.000292
30	372	0.000309
40	410	0.000340
50	420	0.000352
70	502	0.000409
90	502	0.000410
	Fumarate-2-C^{14}	
4	818	0.000482
14	1524	0.000910
20	1610	0.000958
40	1990	0.001210
50	1990	0.001215
70	1582	0.000914
85	1440	0.000846
96	1437	0.000846

Although the intermediate steps have yet to be elucidated, the evidence presented indicates that mammalian tissues contain enzyme systems capable of catabolizing maleic acid to carbon dioxide.

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References and Notes

1. W. Sacks and C. O. Jensen, *J. Biol. Chem.* 192, 231 (1951).
2. H. B. Vickery and J. K. Palmer, *ibid.* 218, 225 (1956).
3. These studies were supported by a grant (M-789) from the National Institutes of Health.
4. I wish to acknowledge the assistance of Dr. Irvin H. Sokolic, Dr. Meyer Abrams, Mrs. Ann Lavender, and Mrs. Shirley Sacks in the experimental work.
5. W. Sacks, *J. Appl. Physiol.* 9, 43 (1956).

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Neurotoxoid Interference in Macacus rhesus Infected Intramuscularly with Poliovirus

Numerous experiments in *Macacus rhesus* infected with either Brunhilde (type I) or Lansing (type II) poliovirus and injected, post-infection, with certain neurotoxoids, suggest that detoxified zootoxins interfere with the experimental infection. In the past the experimental disease was induced by direct inoculation of highly paralytogenic poliovirus into the thalamus, or into the parietal or frontal lobes of the brain of the monkey. The toxoid treatment was initiated subcutaneously 1 to 7 days post-infection. The toxoids were derived from venoms of *Naja flava* (Cape cobra), *Naja naja* (Indian cobra), *Naja haja* (Egyptian cobra), and—most important —from *Crotalus terrificus terrificus* (South American rattlesnake). Toxoid production methods and interference results have been published (*1*, *2*).

The present report is concerned with toxoid interference in *Macacus rhesus* 24 hours after intramuscular injection of a highly paralytogenic Mahoney (type I) virus. All *rhesus* used were subjected to a conditioning period of at least 10 days, at the end of which time blood cell counts were made. The presence of "naturally" occurring neutralizing antibodies against homotype virus was studied prior to the interference experiments.

As a source for inducing a uniform infection, pools of Mahoney virus obtained from monkey kidney cell cultures were used throughout these experiments, and virus potencies ($TCID_{50}$) were determined by titrations in the same type of culture. The infecting dose varied from 500,000 to 5,000,000 $TCID_{50}$ in 0.5 ml—the volume injected. With two exceptions, the virus was administered in the right deltoid muscle.

In addition to our routine *Crotalus terrificus terrificus* and *Naja flava* toxoids, a number of substances were tested as interfering agents against 3,125,000 and 5,000,000 $TCID_{50}$ of Mahoney virus. Two toxic substances, crotoxin (*3*) and a sodium salt of crotoxin, as well as two substances detoxified by acetylation, acetyl-crotoxin and acetylated *Crotalus* venom, were tested. A total of 117 animals were used in these experiments.

Group differences between treated animals and controls, within individual experiments, ranged up to 33 percent in favor of treated animals. Similar trends for entire experiments approximated 20 percent. The number of tests for each preparation was small, and no conclusion has been drawn.

Preliminary studies (*2*) with *Crotalus terrificus terrificus* toxoid showed it to be a promising interfering agent, and it was therefore incorporated into the standard *Naja flava* preparation in the proportion of 1 to 5. Observations made in 82 *rhesus* in three experiments have shown this combination to be the most effective toxoid to date.

Twenty-four hours after intramuscular infection with 500,000 $TCID_{50}$ of Mahoney virus, the mixture of *Crotalus terrificus terrificus* and *Naja flava* toxoids was administered subcutaneously, and this administration was continued on the 2nd, 3rd, 4th, and 7th days. Sixty-eight monkeys received treatment with varying volumes of three different lots of *Crotalus terrificus terrificus* toxoid, diluted (1:5) with *Naja flava* toxoid (Table 1). Thirty days after injection of virus the experiment was concluded, and the percentage of paralysis-free survivors in the treated groups was statistically evaluated in relation to control groups (*4*).

Table 1. Toxoid interference in *Macacus rhesus* 24 hours after intramuscular injection with 500,000 $TCID_{50}$ of Mahoney poliovirus (statistical analysis).

Toxoid injected (ml)	Total No. of *rhesus*	Paralyzed		Paralysis-free		Difference between test and control animals (%)
		No.	%	No.	%	
0.2	8	6	75.0	2	25.0	10.7
0.4 and 0.6	28	15	53.6	13	46.4	32.1
0.9 and 1.0	20	9	45.0	11	55.0	40.7
1.3	12	9	75.0	3	25.0	10.7
None (control saline)	14*	12	85.7	2	14.3	
All toxoid treated	68	39	57.4	29	42.6	31.8†
All comparable controls	37*	33	89.2	4	10.8	

* Twenty-three additional controls tested for *rhesus* reactivity to 500,000 $TCID_{50}$ of virus injected intramuscularly under identical experimental conditions were included by the statistician.

† $X^2 = 9.84$; $p = 0.01$ for $X^2 = 6.635$; $p = 0.001$ for $X^2 = 10.827$; results are significant near 0.1 percent level (0.001).

When the survivors of the interference groups receiving 0.4 ml and 0.6 ml of toxoid were combined and compared with their controls, a difference of 32.1 percent of paralysis-free animals in favor of the treated groups was observed (Table 1). This difference is statistically significant ($p < 0.05$). The 95-percent confidence interval is 5.5 to 58.7 percent.

The difference in favor of groups receiving 0.9 ml and 1.0 ml of toxoid was 40.7 percent (Table 1). The 95-percent confidence interval is 11.6 to 69.8 percent. When *all* toxoid treated animals were compared with all controls, and the results were statistically analyzed, the X^2 value found was 9.84. The result in favor of toxoid treatment is significant almost at the 1:1000 level (Table 1).

The degree of virus spread 24 hours after infection—that is, when treatment was initiated—was investigated. The infecting agent was found at the site of inoculation and in the corresponding brachial plexus. No virus was detected in the central nervous system. In one instance virus was found in the corresponding axillary lymph nodes and in mesenteric lymph nodes. These findings are essentially in agreement with similar experiments in cynomolgus monkeys (*5*).

In the screening tests for naturally occurring antibodies which had been carried out prior to selection of animals for experiments, an incidence of 4 percent of homotype antibodies at serum dilution levels up to 1 to 10 had been demonstrated. This "natural" immunity was not sufficient to protect the monkeys against the experimental infection here described. Nevertheless, no animal with antibodies received toxoid in any interference experiment. As an extension of the antibody study, serological tests were made on 15 survivors, free of paralysis, from one experiment. While three of the six paralysis-free animals from the groups that had received 0.2 ml and 0.4 ml of toxoid, respectively, had antibodies at the 1:500 serum dilution level, only one of eight paralysis-free survivors that had received 0.6 ml and 1.0 ml of toxoid had antibodies at the same level. One paralysis-free control had antibodies at the 1:10 level. Thirty-eight days after the antibody study these animals were reinfected with 10 times the amount of Mahoney virus they had previously received. None of these animals developed paralysis. This resistance could not be correlated with the number of circulating antibodies.

Neuropathologic studies were carried out on representative paralyzed and paralysis-free animals from different experiments. The classical tissue changes in the central nervous system associated with paralysis were demonstrated in affected animals. No pathology was found in paralysis-free survivors, regardless of whether they were control or treated animals.

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References and Notes

1. M. Sanders, M. G. Soret, B. A. Akin, *Bacteriol. Proc. (Soc. Am. Bacteriologists) 53*, (12 Aug. 1953); *Ann. N.Y. Acad. Sci.* 58, 1 (1953); M. Sanders, B. A. Akin, M. G. Soret, *Acta Neurovegetat. (Vienna)* 8, 362 (1954); M. Sanders, M. G. Soret, B. A. Akin, *J. Pathol. Bacteriol.* 68, 237 (1954).

2. M. Sanders, M. G. Soret, B. A. Akin, *Acta Neurovegetat.* (*Vienna*). Published as a monograph, *A Review and Extension of a Six-year Project*, presented at the International Congress on the Neurovegetative System, Strasbourg, France, 1955; M. Sanders, B. A. Akin, M. G. Soret, *Venoms* (Am. Assoc. Advanc. Sci., Washington, D.C., 1956), p. 311.
3. K. Slotta and H. Fraenkel-Conrat, Nature **142**, 213 (1938).
4. We extend our sincere thanks to Iris Kiem, biostatistician, department of medicine, Medical School, University of Miami, for the statistical analysis which she so kindly prepared and which has been presented here.
5. H. A. Wenner and P. Kamitsuka, *Virology* **3**, 429 (1957).

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Shift of Oxidases with Morphogenesis in the Slime Mold, Physarum polycephalum

The slime mold, *Physarum polycephalum*, is one of those unusual organisms which can pass from an acellular, plasmodial stage to a cellular, spore stage during its life cycle (*1*), and as such represents an ultimate in morphogenetic expression. The sequential nuclear events accompanying this change in morphology include synchronous, mitotic, nuclear divisions (*2*) and probably meiosis when uninucleate spores are formed in the mature sporangium (*3*). Since both stages can be obtained at will in the laboratory, this organism lends itself well to a comparative metabolic study capable of yielding information relating to those physiological factors which may control or trigger the process of nuclear division and concomitant spore formation. Such an introductory metabolic study is, therefore, the purpose of this report and is concerned with the comparison of the activities of two oxidases in both stages of the organism (*4*).

Preparation of active homogenates from the plasmodial stage of this organism has been described previously (*5*). The use of sonic oscillations for the disruption of spores was found to be effective in the preparation of spore homogenates (*6*).

Table 1. Comparison of oxidase activities in plasmodial and spore stages in the slime mold, *Physarum polycephalum*.

Cytochrome oxidase		Ascorbic acid oxidase	
*K**/mg of protein N	Spore/plasmodium	*K*†/mg of protein N	Spore/plasmodium
	Spore		
0.081		0.041	
	Plasmodium		
0.028	2.9/1	0.252	1/6.1

* $K = 2.3$ log [reduced cytochrome c] per second.
† $K = 2.3$ log [ascorbic acid] per second.

Allen and Price (*7*) first suspected the presence of cytochrome oxidase in *Physarum polycephalum* on the basis of inhibitor studies on whole plasmodia and a positive Nadi reaction on crushed plasmodia. We have been able to demonstrate that cytochrome oxidase is indeed present in homogenates of both plasmodial and spore stages by following the enzymic oxidation of reduced cytochrome *c* at 550 mμ in the Beckman spectrophotometer. Although the kinetics of mammalian cytochrome *c*–cytochrome oxidase reaction has been reported as obeying a combination of first-order and zero-order reactions (*8*), the conditions of our experiments reveal only first-order concurrence with the identical system in *Physarum*. This is in agreement with the cytochrome *c*–cytochrome oxidase first-order reaction rates in other preparations (*9*). First-order velocity constants were, therefore, calculated from the slope of the plots of 2.3 log reduced cytochrome *c* versus time. These constants were observed to be directly proportional to the amount of enzyme used in the reaction mixture; and when they are related to protein nitrogen content, they can be used as a true measure of cytochrome oxidase activity in each cell-free stage of the life cycle of the organism.

In an attempt to measure cytochrome oxidase activity in the plasmodial stage, Holter and Pollock (*10*) used the indirect manometric method of Schneider and Potter (*11*), which requires the use of ascorbic acid as a reductant of cytochrome *c*. Upon subsequent examination of this system, it was shown that the electrons from ascorbic acid not only pass through the cytochrome system but are also mediated to oxygen by an atypical ascorbic acid oxidase (*5*). These two systems can be separated by differential centrifugation, since the ascorbic acid oxidase is not associated with a particulate fraction and can be retained in the supernatant of a 25,000 *g* centrifugation; this supernatant is in turn devoid of cytochrome oxidase activity. The ascorbic acid oxidase activity is atypical, since it is resistant to the usual metallorespiratory inhibitors, forms hydrogen peroxide as an oxidation end product, and requires the presence of an unknown inherent sulfhydryl compound for which diethyldithiocarbamate or its disulfide can be substituted. Since it has been shown previously that the ascorbic acid–ascorbic acid oxidase system in *Physarum* obeys first-order reaction kinetics (*5*), then first-order velocity constants can also be obtained and validated as a measure of enzyme activity, as is described above.

A comparison of the oxidase activities in both the plasmodial and spore stages, shown in Table 1, reveals a shift in oxidases as the organism undergoes spore formation. Whereas there is approximately three times as much cytochrome oxidase activity in spores as in plasmodia, there is approximately six times as much ascorbic acid oxidase activity in the plasmodia as in spores.

The physiological interpretation of this shift is obscure at present, since information regarding metabolic patterns in this organism is lacking. However, these results do indicate that the atypical ascorbic acid oxidase, heretofore not rigidly established as a terminal oxidase, is not without definite function but by virtue of this shift may play an important role in the metabolism of the organism. Further, since energy is required for the nuclear divisions and formation of spore walls, a possible explanation for the increase of cytochrome oxidase activity can be offered on an energetic basis; those phosphorylation reactions necessary for the production of high-energy phosphate compounds have been demonstrated to occur in discreet stages of the cytochrome system participating in cellular oxidations (*12*).

This shift in oxidases may be fundamental to all organisms but may well be masked in organisms which undergo cellular division but which are constantly in the cellular state.

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References and Notes

1. F. L. Howard, *Am. J. Botany* 18, 116 (1931).
2. ———, *Ann. Botany* (*London*) **46**, 461 (1932).
3. C. M. Wilson and I. K. Ross, *Am. J. Botany* **42**, 743 (1955).
4. A portion of this work was completed during the tenure of a Lalor Foundation summer faculty fellowship. This research was aided by grants from the National Science Foundation (G-1930) and the Temple University Committee on Research. I am indebted to John Tyler Bonner for his criticisms and suggestions in the preparation of the manuscript.
5. J. M. Ward, *Plant Physiol.* 30, 58 (1955).
6. Unpublished experiments.
7. P. J. Allen and W. H. Price, *Am. J. Botany* 37, 393 (1950).
8. W. J. Frajola and C. S. Vestling, *J. Biol. Chem.* **209**, 677 (1954).
9. L. Smith, in *Methods of Biochemical Analysis* (Interscience, New York, 1955), vol. 2.
10. H. Holter and B. M. Pollock, *Compt. rend. trav. lab. Carlsberg. Sér. chim.* 28, 221 (1952).
11. W. C. Schneider and V. R. Potter, *J. Biol. Chem.* **149**, 217 (1943).
12. M. Friedkin and A. L. Lehninger, *ibid.* 177, 775 (1949).

4 November 1957

Book Reviews

An Introduction to Algebraic Topology. Andrew H. Wallace. Pergamon Press, New York, 1957. vii + 198 pp. Illus. $6.50.

In this very readable and carefully motivated book on algebraic topology the author has successfully filled a gap in the mathematical literature which has existed for years. He has provided an understandable elementary textbook in algebraic topology, available to the beginning student with no more than the usual basic training in algebra and analysis, and he has done so without reducing the subject to the meaningless game of cutting and pasting and rubber-sheet stretching which usually results from efforts of this kind.

After introducing the usual elementary topological notions in the first three chapters, he starts on the principal guiding theme of the book, a discussion of continuous transformations and homotopy. The fundamental group is discussed first, and then the homology groups are introduced by means of the singular homology theory. The excision theorem is proved, as are also the topological invariance of the homology groups and their invariance under deformations. The final two chapters of the book consist of a treatment of the homology sequence and of methods of calculating homology groups of various spaces by making use of the exactness of the homology sequence. Simplicial complexes are introduced in the last chapter, and the treatment of their homology characteristics is given, not directly in terms of incidence relations but indirectly in terms of exact sequences and singular homology.

The book is liberally supplied with illustrations, which aid in clarifying the intuitive discussion which precedes almost all theorems before their formal proofs are given. Most of the applications to the properties of particular spaces and to investigations of continuous transformations are given in numerous, well-chosen exercises which, as the author states in the preface, form an integral part of the book.

By making fundamental use of the current techniques of algebraic topology the author has brought before the elementary student and the nonspecialist a well-motivated and coherent treatment of subjects heretofore only available in research papers and in piecemeal form. The book is not one into which one can dip at random with any degree of success, but one which must be read from beginning to end for a true appreciation of its contents. As is inevitable in a work of this type, many interesting topics are mentioned only in passing or not at all, but on the whole the author has succeeded remarkably well in giving a connected, lucid, and elementary account of present-day methods in algebraic topology.

ROBERT E. FULLERTON
University of Maryland

The Reproductive Development of the Female. With especial reference to the period of adolescent sterility. A study in the comparative physiology of the infecundity of the adolescent organism. M. F. Ashley Montagu. Julian Press, New York, ed. 2, 1957. xviii + 234 pp. Illus. $5.

Anthropologists and ethnologists have long wondered why in nonliterate societies girls seldom become pregnant during early postpubertal years, despite their promiscuous sexual relations during this period. Among the scientists who "wondered" was the author of this book, who determined to find an explanation for the phenomenon, which he felt was genuine and not a spurious artifact. Observations of Mirskaia and Crew on the mouse (1930) and of Hartman on the rhesus monkey (1931) provided him, he says, with the necessary evidence to warrant further study. The result was the preparation of an extensive essay on the subject: "Adolescent Sterility" [*Quart. Rev. Biol.* (1939)]. This was expanded into a book with the same title in 1946, in which the author brought together much of the world's literature on the subject.

Since, during the last decade, more data have accumulated in this area, the author has now prepared the new edition under the title *The Reproductive Development of the Female*, condensing the old and adding the new. The ethnological data are presented in the chapter "Adolescent sterility in man," while the material on adolescent sterility in lower animals has been greatly expanded. The "Biology of adolescent sterility" affords a scientific background for the study; it is written in a manner quite satisfactory to the student of the physiology of reproduction. Psychological factors are briefly discussed, and some social implications are pointed out.

The book is written in the author's well-known clear and pleasing style, which makes the reading almost effortless. The basic facts are presented in 55 well-selected tables, and there is a bibliography of over 400 titles, many of which, for the readers' convenience, are given as footnotes in appropriate places.

The author may be said to have completely answered the question he set out to answer: "What, if any, interval of time elapses between the appearance of the first menstruation, the menarche, and the ability to conceive and carry a fetus to term?" While the interval between the menarche and the first conception is subject to very wide variations, it is a matter of some two, three, four or more years. The author is, however, cognizant of the exceptional cases of early motherhood and has, in the bibliography, assembled dozens of references to precocious pregnancies. He has also assembled interesting figures on the age at menarche in different countries, age at first parturition, interval between marriage and first delivery in regions where girls are married soon after the first menstruation, adolescent sterility in the male, and other related topics.

The present study on adolescent sterility has, in my opinion, been so thoroughly executed that another book on this unique subject will not soon be called for.

CARL G. HARTMAN
Ortho Research Foundation

Trophoblastic Growths. Aclinical, hormonal and histopathologic study of hydatidiform mole and chorionepithelioma. J. Smalbraak. Elsevier, Amsterdam, 1957. $12.75.

Biologically, hydatidiform mole and chorionepithelioma are of great interest since the production of chorionic gonadotrophin by these tumors makes it possible to follow all their vicissitudes by means of biological assay methods. At the moment this is the only human tumor for which such a test exists. Unfortunately, the value of assays has been obscured by the use of urine rather than blood serum.

Smalbraak devotes many pages to the pitfalls of urinary assay, especially the occurrence of negative tests in spite of the presence of tumor. However, a method of assay in which blood serum in immature (21 to 23-day) female rats is used has been available since 1941 [E. Delfs, *Endocrinology* **28**, 196 (1941)]. Delfs has recently published the results of her studies [*Obstetrics and Gynecology*, **9**, 1 (1957)], unfortunately, too late to have come to Smalbraak's attention. Since chorionic gonadotrophin levels in blood are much higher than in urine, Delfs' serum assay method produces no false negative results and is the most valuable single criterion for diagnosis and prognosis of hydatidiform mole and chorionepithelioma.

This book is the first modern monographic presentation of the subject. It is written in a clear, easy style, is reasonably exhaustive, and very beautifully illustrated. The case histories of the 74 hydatidiform moles and 17 chorionepitheliomas encountered at the Utrecht University Clinic, presented in every detail, provide a complete and fascinating picture of all the posible biologic variations of these tumors. American students of the subject may be surprised by the relative neglect of Arthur Hertig's early paper on the etiology of hydatidiform mole [A. T. Hertig and H. W. Edmonds, *Arch. Pathol.* **30**, 260 (1940)] and the considerable emphasis on his later grading of hydatidiform mole according to relative malignancy [A. T. Hertig and W. H. Sheldon, *Am. J. Obstet. Gynecol.* **53**, 1 (1947)], which has not been universally accepted. This, however, can scarcely detract from the extreme value of this book to everyone concerned with the biology of cancer.

GEORGE W. CORNER, JR.
Johns Hopkins Hospital

Principles of Stratigraphy. Carl O. Dunbar and John Rodgers. Wiley, New York; Chapman & Hall, London, 1957. 356 pp. Illus. $10.

This pleasing volume fills a long-felt need in geological literature. While the primary objective in its preparation may have been to provide an adequate textbook for a graduate course in stratigraphy, it will accomplish not only this but will also undoubtedly find a very useful place in the bookshelves of all geologists who are interested in sedimentary rocks.

Part I (95 pages) deals principally with general processes of transportation and deposition of sediments and with the characteristic features of the deposits of various environments: fluvial, desert, lake, glacial, neritic, bathyal, abyssal, cliffed shore, beach, tidal flat, lagoon, estuary, delta, and organic reef.

Part II (60 pages) is concerned with the nature of stratification, unconformities and diastems, and facies changes.

Part III (97 pages) covers the nomenclature of sedimentary rocks in general and the description and genesis of individual lithologic types, classified under the chapter headings of "Rudites," "Terrigenous arenites," "Lutites," "Redbeds," "Carbonate rocks," and "Siliceous non-fragmental rocks."

Finally, part IV (61 pages) discusses stratigraphic classification; the nature of stratigraphic units, with discussion of usage and terminology, and principles of correlation; and broad patterns in the distribution of sedimentary rocks.

The text is illustrated with 123 figures consisting of well-chosen photographs and simple, clear diagrams and sketches. There are 20 pages of bibliography and 15 pages of subject index. The format of the book is excellent, and it is remarkably free from typographical errors.

I found the subject matter extremely interesting and stimulating. The scholarly background and broad experience of the authors is evident throughout in the richness of reference and example. Particularly to be commended is the fact that, in the discussion of sedimentary processes, environments of deposition, lithologic types, and stratigraphic principles, numerous specific illustrative examples are cited from various parts of the stratigraphic column and from various parts of the world.

Stratigraphy is a dynamic subject. We are far from having heard the last word on many of the topics touched upon in this book, and on many there still is spirited controversy. This is recognized by the authors, and, while they state their own views, they have in general taken an open-minded and broadly tolerant attitude toward the opinions of others. Not even the authors always agree, and doubtless most stratigraphers will find occasional passages in the book to which they will object. It seems to me that too much is made of the need for a special agent, "turbidity currents," to explain the common phenomenon of graded bedding. In addition, the definition of a desert as an area with interior drainage does not seem very adequate; the use of chemical methods in distinguishing marine from nonmarine sediments might have been mentioned; in the treatment of "facies changes" too much emphasis is placed on lateral as compared with vertical variations; there is little need for the terms *biotope* and *lithotope*. The statement that mud cracks are one of the best evidences of nonmarine deposition also seems questionable; there is insufficient emphasis on the increasing importance of radioactive methods in the dating of sedimentary rocks; and the statement that a certain paper on stratigraphic terminology published in 1941 has been the basis for all further thinking on the subject in America will undoubtedly be challenged.

However, while exception may be taken to a few statements and omissions, the book as a whole is outstandingly comprehensive and authoritative, and it should become a standard text and reference work. More than that, the authors are to be congratulated on having produced a work which it is impossible to read without being inspired with renewed enthusiasm for the fascinating field of stratigraphy.

HOLLIS D. HEDBERG
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Language: An Enquiry into Its Meaning and Function. Ruth Nanda Anshen, Ed. Harper, New York, 1957. xviii + 366 pp. Illus. $6.

In the introduction to this volume, the editor suggests that the problem being discussed is "the mystery, the miracle, and the magic of language." This suggests a kind of mystical approach to linguistic phenomena which, unfortunately, recurs through many of the 19 essays which comprise the book. Surely, we must be at least a little skeptical about any theory of language which asks at the outset that we "concede that . . . language . . . must come from God" and which insists that language "is the proof of the existence of God." As a matter of fact, one criticism of this work is precisely that, in spite of the editor's claim of homogeneity, the book presents no coherent theory about language at all but is merely a collection of uncoordinated and often contradictory essays of varying merit, by contributors with a wide range of interests. Thus, whereas one author tells us that it is futile to search for the origin of language, another devotes his entire study (39 pages) to a not-too-convincing discussion of this very topic.

There is a very real need for a comprehensive treatment of language which will in some way illustrate the relative positions of such disciplines as linguistics, philosophy, logic, psychology, literary criticism, and so forth. Such a study presumably would indicate to what extent the findings of investigators in different fields are complementary and can be reconciled with one another and to what degree there is genuine disagreement. This book does not help satisfy the need. It is unfortunate that the few essays which do contain clear and stimulating ideas are not numerous enough to overcome the impression that the editor has created—namely, that language is a metaphysical phenomena that cannot be understood by the techniques and resources of a scientific method. Much of current research in this area is dedicated to demonstrating precisely the opposite.

Sol Saporta

Department of Spanish and Portuguese, Indiana University

Insect Life in the Tropics. T. W. Kirkpatrick. Longmans, Green, New York, 1957. xiv + 311 pp. Illus. $7.

In the past century, science, and with it entomology, has become an area for the expert. The rigorous code of the latter, especially in the publication of results, has all but driven the amateur natural historian from the field. Yet, in the opinion of many scientists, the amateur is the primordium of the professional and, therefore, he should be attended. The large body of popular writings on science appearing under recognized names indicates that he is, and that popular works increasingly enjoy the regard of professionals.

Now this excellent little volume on tropical entomology joins the distinguished books of Hoyle, Gamow, and many others in its encouragement of the amateur. It may be too good for him. The opening chapters of the book are organized on the plan of a textbook on entomology; insect structure and classification are given—briefly, it is true, but with little sacrifice of technical accuracy to so-called popular appeal. The sections that follow comprise an entertaining potpourri of facts about tropical insects, in chapters rather loosely headed "Development," "Reproduction," "Food and feeding," "Defense and protection," and "Insect communities." These make delightful reading, although the expert will be mildly irritated by the lack of specific citations to literature and of rigid subject categories, in which the author had to make some compromises for the sake of brevity. The many diagrams, photographs, and drawings are well done. This book is highly recommended.

Joseph H. Young

Department of Zoology, Tulane University

Thermodynamics and Statistical Mechanics. A. H. Wilson. Cambridge University Press, New York, 1957. xv + 495 pp. Illus. $9.50.

The author states that his aim is to give a somewhat critical account of thermodynamics and statistical mechanics intended mainly for theoretical physicists. However, the lucidity, charm, and succinctness of his style will doubtless appeal to a wider audience. Many physical chemists, physical metallurgists, and experimental physicists or graduate students needing a review of these fields will be included.

The initial four chapters (90 pages) are devoted to thermodynamics, starting with two on the classical development of the first and second laws of thermodynamics from first principles. The presentation is so clear and easy to follow that superior undergraduates could use it for collateral reading, even in a first course. Thermodynamic functions and the myriad equations in which they appear are neatly treated next, and Caratheodory's axiomatic foundation of thermodynamics is clearly presented in the fourth chapter.

Chapters five and six (88 pages) discuss statistical mechanics and some of its simple applications (general principles, connection with thermodynamics, fluctuations, quantum statistics, perfect gases, crystalline solids, radiation). In library copies, these pages will probably be particularly well worn by generations of graduate students. The next chapter, on the third law of thermodynamics, rounds out the discussion of general laws and their most immediate applications.

The last four-sevenths of the book (280 pages) comprise seven chapters, on applications to imperfect gases, heterogeneous equilibrium, electric and magnetic phenomena (mostly solid state), gas mixtures and chemical reactions, solutions, electrochemical systems, and some additional topics in solids (rubber and order-disorder). They are all fine graduate-level introductions, but as the book is a text rather than a reference work, those particularly interested in special topics may want to consult the references at the ends of the chapters. These are fairly current, and though far from exhaustive, include many important papers, texts, and reviews. Topics traditionally in the field of physical chemistry are treated in sufficient detail to satisfy most physicists, but chemists would probably want to go further. Though many topics in solid-state physics are treated (besides those cited, there are discussions of ferroelectricity, paramagnetic substances, ferromagnetism, antiferromagnetism, and superconductivity in the chapter on electric and magnetic phenomena), the theory of lattice defects, semiconductors, and thermionic emission is omitted, and theory of metals (treated by the author in another book) is barely touched. While cooperative phenomena might perhaps be treated most elegantly together, four such cases are discussed in the chapter on electric and magnetic phenomena, one in the chapter on additional topics in solids, and one (superfluidity) in the chapter on heterogeneous equilibrium, with a bit on rotational transitions tucked away in the chapter on the third law. But this is a minor matter when balanced against the eminent success of the author's attempt to achieve his stated aims.

A number of misprints were found: "constant-value" appears where "constant-volume" should be (second paragraph, page 70); a subscript "II" should be "I" on page 276, equation 9.42.2; summation over *i* should be indicated in the second term on the right of equation 11.321.1 on page 366; the reference to "fig. 8.9 of page 226" above table 11.1 on page 370 should be to figure 8.8 on page 224; on page 436, line 2, "grounds" should be changed to "groups," and on page 448 the "lo" has disappeared from parallelopiped.

Jerome Rothstein

Edgerton, Germeshausen & Grier, Boston, Massachusetts

Induced Delusions. The psychopathy of Freudism. Coyne H. Campbell. Regent House, Chicago, 1957. xx + 189 pp. $4.

This book is an attempt to "expose" psychoanalysis and to eject psychoanalytic theory from medical school curricula. The author believed that analytic concepts and theories were fantasies and hypnotically conditioned delusions of no scientific or therapeutic value. The entire volume is replete with strongly emotional statements which are frequently confused, contradictory, and inaccurate. It is much too revealing in ways that were not intended. It cannot be recommended for any serious reader.

Dana L. Farnsworth

Harvard University

Dangerous Properties of Industrial Materials. A completely revised and enlarged edition of *Handbook of Dangerous Materials.* N. Irving Sax. Reinhold, New York; Chapman & Hall, London, ed. 2, 1957. vii + 1467 pp. $22.50.

In this encyclopedic reference volume the author and his assistants have presented a rewritten and enlarged version of Sax' *Handbook of Dangerous Materials* (1951). This volume discusses 8500 materials in approximately 1500 pages, whereas the earlier volume devoted 850 pages to 5000 materials.

The objective of the earlier volume was to provide a conveniently arranged reference work on the hazardous properties of chemical compounds and other industrial materials with emphasis on what precautionary measures should be taken to handle them safely.

The 12 sections comprising the enlarged edition are conveniently thumbindexed, and carry the following titles: "Toxicology," "Ventilation control," "Personnel protection and personal hygiene," "Atmospheric pollution," "Radiation hazards," "Industrial fire protection," "Storage and handling of hazardous materials," "Reactor safeguards," "Allergic disease in industry," "General chemicals," "Shipping regulations," and "Index to synonyms."

The largest section, over 1000 pages, is the one on general chemicals. The various materials are alphabetically arranged and presented under such subjects as synonym, description, formula, physical constants, toxic hazard rating, fire hazard, explosion hazard, disaster control, ventilation control, personal hygiene, and storage and handling. The section on shipping regulations, of some 160 pages, is the next largest in size. This section reproduces appropriate text, tables, and shipping labels from the regulations of the Interstate Commerce Commission (Bureau of Explosives). The remaining sections, varying in length from 8 to 56 pages, bring together additional helpful information related to safety.

This handbook should be found useful not only by persons responsible for producing and maintaining a safe and healthful occupational environment but also by editors, technical writers, investigators, and others engaged in providing information for the improvement of the work environment.

W. M. GAFAFER

Occupational Health Program,
U.S. Public Health Service

New Books

The Voyage of the Lucky Dragon. Ralph E. Lapp. Harper, New York, 1958. 213 pp. $3.50.

The Bacteriology of Tuberculosis. Egons Darzins. University of Minnesota Press, Minneapolis, 1958. 499 pp. $10.

Nuclear Masses and Their Determination. Proceedings of the conference held in the Max-Planck-Institute für Chemie, Mainz, 10–12 July 1956. H. Hintenberger, Ed. Pergamon Press, New York and London, 1957. 276 pp. $14.

Ion-Exchange Resins. J. A. Kitchener. Methuen, London; Wiley, New York, 1957. 116 pp. $2.

The Strategy of the Genes. A discussion of some aspects of theoretical biology. C. H. Waddington. Macmillan, New York, 1957. 271 pp. $4.

The Grasshoppers and Locusts (Acridoidea) of Australia. vol. III, *Family Acrididae: Subfamily Cyrtacanthacridinae. Tribes Oxyini, Spathosternini, and Praxibulini. James* A. G. Rehn. Commonwealth Scientific and Industrial Organization, Melbourne, Australia, 1957. 273 pp.

The Quest for Identity. Allen Wheelis. Norton, New York, 1958. 250 pp. $3.95.

God's World and You. O. A. Battista. Bruce, Milwaukee, Wis., 1957. 244 pp. $3.95.

Bridges and Their Builders. David B. Steinman and Sara Ruth Watson. Dover, New York, rev. ed., 1957. 417 pp. $1.95.

Selections from Modern Abstract Algebra. Richard V. Andree. Holt, New York, 1958. 224 pp. $6.50.

Electrical Discharges in Gases. F. M. Penning. Macmillan, New York; Philips, Eindhoven, Netherlands, 1958. 83 pp. $3.

Plant Design and Economics for Chemical Engineers. Max S. Peters. McGraw-Hill, New York, 1958. 522 pp. $11.

Biophysical Chemistry. vol. I, *Thermodynamics, Electrostatics, and the Biological Significance of the Properties of Matter.* John T. Edsall and Jeffries Wyman. Academic Press, New York, 1958. 714 pp. $14.

Magnesium. The fifth major plant nutrient. A. Jacob. Translated from the German by Norman Walker. Staples Press, London, 1958. 171 pp. 40s.

Chemistry of Carbon Compounds. A modern comprehensive treatise. vol. IV, pt. A, *Heterocyclic Compounds.* E. H. Rodd, Ed. Elsevier, New York, 1957 (order from Van Nostrand, Princeton, N.J.). 833 pp. $28.

Around the World in 90 Minutes. The fabulous true story of the man-made moons. David O. Woodbury. Harcourt, Brace, New York, 1958. 248 pp. $5.75.

Film Formation, Film Properties, and Film Deterioration. A study by the Research Committee of the Federation of Paint and Varnish Production Clubs. Charles R. Bragdon, Ed. Interscience, New York, 1958. 437 pp. $9.75.

Science and the Creative Spirit. Essays on humanistic aspects of science. Karl W. Deutsch, F. E. L. Priestley, Harcourt Brown, David Hawkins. Harcourt Brown, Ed. University of Toronto Press, Toronto, Canada, 1958. 192 pp. $4.50.

Explorations in Role Analysis: Studies of the School Superintendency Role. Neal Gross, Ward S. Mason, Alexander W. McEachern. Wiley, New York; Chapman & Hall, London, 1958. 393 pp. $8.75.

Science in Everyday Things. William C. Vergara. Harper, New York, 1958. 316 pp. $3.95.

Fundamentals of Mathematics. M. Richardson. Macmillan, New York, rev. ed., 1958. 525 pp. $6.50.

General Chemistry. A first course. L. E. Young and C. W. Porter. Prentice-Hall, Englewood Cliffs, N.J., ed. 4, 1958. 639 pp. $6.75.

Better Report Writing. Willis H. Waldo. Reinhold, New York; Chapman & Hall, London, 1957. 238 pp. $4.75.

Distributional Check-List of the Birds of Mexico. pt. II, *Pacific Coast Avifauna, No. 33.* Cooper Ornithological Society, Berkeley, Calif., 1957. 436 pp.

Physico-Chemical Effects of Pressure. S. D. Hamann. Academic Press, New York; Butterworths, London, 1957. 246 pp. $8.50.

Structure Reports, 1951. vol. 15. A. J. C. Wilson, Ed. International Union of Crystallography and Oosthoek, Utrecht, Netherlands, 1957. 588 pp.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

The Relationships between Electroencephalographic and Psychological Data in Normal Adults. P. F. Werre. Universitaire Pers Leiden, Leiden, Netherlands, 1957 (order from Martinus Nijhoff, Lange Veerhout 's-Gravenhage). 152 pp. F. 15.

Public Law Problems in India. A survey report. Proceedings of a conference held at the Stanford Law School, 15 July–16 August 1957. Lawrence F. Ebb, Ed. Stanford University, Stanford, 1957. 194 pp. $2.50.

Notes on Some Brazilian and Other Leguminosae. Contributions from the U.S. National Herbarium, vol. 29, pt. 12. Arturo Burkart. 7 pp. *Diagnostic Characteristics of the Fruits and Florets of Economic Species of North American Sporobolus.* vol. 34, pt. 1. Vera Lyola Colbry. 24 pp. Smithsonian Institution, Washington, D.C., 1957.

The Medical and Veterinary Importance of Cockroaches. Smithsonian Misc. Collections, vol. 134, No. 10. Louis M. Roth and Edwin R. Willis. 147 pp. *Permian Brachiopods from Central Oregon.* vol. 134, No. 12. G. Arthur Cooper. 79 pp. *Morphology and Taxonomy of the Foraminiferal Genus Pararotaliz Le Calvez, 1949.* vol. 135, No. 2. Alfred R. Loeblich, Jr., and Helen Tappan. 24 pp. *Mineralogical Studies on Guatemalan Jade.* vol. 135, No. 5. William F. Foshag. 60 pp. *A Revised Interpretation of the External Reproductive Organs of Male Insects.* vol. 135, No. 6. R. E. Snodgrass. 60 pp. Smithsonian Institution, Washington, D.C., 1957.

Federal Grants and Contracts for Unclassified Research in the Life Sciences. Fiscal year 1956. National Science Foundation, Washington 25, 1957. 241 pp.

The Old Copper Culture and Keweenaw Waterway. Fieldiana: Anthropology, vol. 36, No. 8. George I. Quimby and Albert C. Spaulding. 13 pp. $0.40. *New Birds from the Philippines.* Philippine Zoological Expedition, 1946–1947. Fieldiana: Zoology, vol. 42, No. 2. Austin L. Rand and D. S. Rabor. 6 pp. $0.15. Chicago Natural History Museum, Chicago, 1957.

Protoplasmatologia, Handbuch der Protoplasmaforschung. Band I, *Grundlagen*; 1956; 1956. 162 pp. $12.40. Band II, *Cytoplasma*; 1957. 43 pp. $7.40. L. V. Heilbrunn and F. Weber, Eds. Springer, Vienna.

Anthropological Papers, Numbers 49–56. Bureau of American Ethnology Bull. 164. Smithsonian Institution, Washington, 1957 (order from Supt. of Documents, GPO, Washington 25). 355 pp. $2.75.

Geochemical Prospecting. General reconnaissance methods. Nalin R. Mukherjee and Leo Mark Anthony. University of Alaska, College, 1957. 81 pp. $2.

Danish Review of Game Biology. vol. 3, pt. 2. R. Spärck and H. M. Tamdrup, Eds. Schultz, Copenhagen, Denmark, 1957. 131 pp.

Meetings and Societies

Nuclear Structure

On 8–14 September 1957 an International Conference on Nuclear Structure was held at the Weizmann Institute of Science in Rehovoth, Israel. Approximately two hundred physicists, representing 15 different countries, attended this conference, which was sponsored by UNESCO, the International Union of Pure and Applied Physics, the Israel Atomic Energy Commission, and the Weizmann Institute of Science. The excellent organization of the conference by the secretary, A. de Shalit, and by the staff of the Weizmann Institute was an important factor which contributed greatly to its success.

The half-day sessions consisted of two or three invited lectures followed by discussion periods or by presentations of short (sometimes very short) contributed papers, or by both. In view of the wealth of material presented, only a limited number of papers can be discussed here in detail. A comprehensive report of the conference will be published in the near future as the "Proceedings of the Rehovoth Conference on Nuclear Structure, 1957" (North-Holland Publishing Company, Amsterdam).

The first two days of the conference were devoted to discussions of the theory of nuclear models, to the interpretation of nuclear spectroscopy data in the light of the different models, and to considerations of effects of the finite nuclear size. After informal discussions (for which ample time was provided by a sight-seeing trip to Jerusalem, through the courtesy of the Hebrew University, and a reception by the President of the State of Israel, I. Ben-Zvi), the conference continued with a somewhat more diversified program. A whole day's program was concentrated on discussions of the subject of nonconservation of parity and beta-decay in theory and experiment. Sessions devoted to discussions of extranuclear effects, on angular correlation, to the description of nuclear spectroscopy instruments, and to measurements of very short nuclear lifetimes concluded the official part of the conference.

Nuclear models. In the first lecture of the opening session on shell model evidence in nuclei, R. J. Eden (Cambridge) discussed the theoretical foundations of the nuclear shell model. The methods of K. Brueckner (Philadelphia) and his collaborators can be used to study many particle systems in which there are strong two-body forces. The extension of these methods provides a form of perturbation theory which is applicable to low-lying states of nuclei. In the case of a closed shell nucleus, the independent particle model potential can be determined from given two-body forces on the basis of self-consistent equations. Due to degeneracy problems, the formalism is considerably more complicated for nuclei that correspond to a closed shell plus several nucleons.

In the discussion, Brueckner mentioned attempts to understand the collective properties on the basis of an electron gas approach. Also, calculations on the basis of nonlocal interactions are being made at present. B. H. Flowers (Harwell) communicated his calculations of properties of the lithium-7 nucleus, adjusting the parameters of his theory to agree with the observed data of lithium-6. The agreement between the predicted and observed data of lithium-7 is fair. I. Talmi (Weizmann Institute) emphasized the need for a better understanding of the effective two-body forces between nucleons, which are very different from the interactions between free nucleons. Even if these forces were known, the lack of detailed knowledge of the single nucleon radial functions would interfere with any attempt to obtain quantitative results. It is possible, however, on the basis of general assumptions (effective two-body forces, *j-j*-coupling, no change of radial functions going from one nucleon to another) to impose consistency relations on the data and, in this way, to obtain indications whether the assumptions are reasonable. In several cases in which it was possible to analyze the data, quantitative agreement was obtained.

The unified model of the nucleus was the subject of a lecture by B. R. Mottelson (Copenhagen). While many main features of the classification of low-energy nuclear data follow simply from the symmetry properties of the nuclear shape, a more detailed description requires a better understanding of the nature of the correlations involved in the collective motion. R. E. Peierls (Birmingham) presented a discussion on the foundations of the collective model, in which he pointed out that the method developed by Wheeler and Griffin, Peierls and Yoccoz, Skyrme, and others, when applied to the problem of center-of-mass motion, does not automatically give the correct answer for the translational energy. This method can be considered the first step in an expansion in which higher terms represent the difference between the correct two-body forces and the well potential used in the shell model. Higher terms must be taken into account to correct the values of the translational energy as well as the moments of inertia calculated in the rotational case. Unfortunately no numerical results are as yet available.

The main lecture of an evening session of the first day of the conference was given by G. Racah (Hebrew University), who discussed the seniority number and its application to nuclear spectroscopy. The seniority number is the number of particles in a nuclear system which are *not* coupled together with antiparallel angular momenta (nonsaturated particles). The seniority number gives the smallest number of particles needed for building a state with the same properties, and it therefore characterizes the simplest configuration which contains such a state. Certain properties of nuclear states, such as the angular momentum and the magnetic dipole moment (but not the energy), depend essentially on the number of nonsaturated particles (the seniority number), since the "saturated" pairs of particles are spherical symmetric and do not contribute to the above-mentioned nuclear properties.

Electromagnetic transitions and heavy nuclei. The morning session of the second day was opened with a paper by D. Wilkinson (Cambridge) on radiative transitions in light nuclei. Dipole transitions, electric as well as magnetic, seem to follow the general trend expected from the independent particle model. Electric quadrupole transitions, however, show very clearly the effects of collective motion. Effects of isotopic spin selection rules on electric dipole transitions were also discussed by the speaker. No evidence is found for departures from charge independence of the specifically nuclear forces.

In the next lecture, on effects of configuration interaction on electromagnetic transitions, A. de Shalit (Weizmann Institute) pointed out that corrections of higher order must be considered before discrepancies between the zeroth-approximation shell-model predictions and experimental data are studied. The contributions of configuration interaction to transition probabilities as well as the possibility of interference between different contributions must be taken into account. On this basis a fair enhancement of electric quadrupole transition probabilities can be understood, even within the framework of the shell model.

I. Bergstrom (Nobel Institute) presented a survey of experimental data on energy levels and multipole transitions in heavy nuclei ($Z=74$ to $Z=84$). Regularities in the appearance and separation of certain levels can be understood on the basis of predictions of the single-particle shell model. Also, a comparison between observed transition probabilities for multipole gamma transitions and those calculated from the single-particle model was presented. An influence of the magic numbers $Z=82$ and $N=126$ is obvious.

Effects of the finite size of the nucleus. The next session was devoted to effects of the finite size of the nucleus. M. E. Rose (Oak Ridge) presented an excellent review of all the phenomena in low-energy nuclear physics which are affected by the finite nuclear size. The internal conversion of gamma rays can be strongly influenced by the finite size of the nucleus by virtue of two effects: (i) the finite charge distribution of nuclei modifies the wave function of the electron as compared to the case of a point nucleus (static influence), and (ii), due to the penetration of the atomic electrons into the nucleus, the conversion is affected by the actual shape of the charge distribution (dynamic influence). The effects are particularly large (up to 50 percent) for dipole radiation and for very heavy nuclei.

In the following lecture, A. H. Wapstra (Amsterdam) discussed the methods for and the difficulties in obtaining precise experimental values of the probability of internal conversion. According to the speaker, the most precise method consists of a comparison of beta spectra and conversion line intensities. Measurements were presented which clearly showed evidence of the influence of the finite nuclear size on the probability of internal conversion. Other effects of the finite nuclear size include the influence on beta-decay phenomena, in particular on the electron-capture to positron-branching ratio. This latter aspect was discussed by P. F. Zweifel (General Electric).

Parity nonconservation in beta-decay. The sessions on parity nonconservation and beta-decay in theory and experiment were held on 12 September (these sessions were postponed two days because of travel delays of one of the main speakers). The morning session was opened by E. I. Konopinski (Indiana) with an outstanding clear summary of what can be learned about the beta interaction by means of the "classical" experiments—that is, experiments which do not give evidence of parity nonconservation. The classical experiments are, in principle, suited to measure the relative proportions of the Fermi and Gamow-Teller couplings. The electron-neutrino correlations in particular should determine whether the tensor (T) or the axial-vector (A) coupling is responsible for the Gamow-Teller component, and whether the scalar (S) or vector (V) coupling is responsible for the Fermi component. At present, it is not possible to reconcile all experimental data on electron-neutrino-angular correlations with one particular choice of coupling. So far, the contradictions in the different experimental values cannot be resolved by any conceivable generalization of the theory. Clearly, better and more of the "classical" electron-neutrino correlation measurements are needed before a final answer as to the beta coupling constants can be given.

The theoretical implications of parity violation in beta interactions were discussed by T. D. Lee (Columbia). The fact that now all experimental data on the longitudinal polarization of electrons emitted in a beta-decay process are compatible with a polarization of $-v/c$, whereas data on positrons agree with a longitudinal polarization of $+v/c$, gives strong support to the two-component theory of the neutrino. The physical aspect of this theory is that the spins of all neutrinos are parallel to their momentum, whereas the spins of all antineutrinos are in a direction opposite to their momentum. On the basis of this theory, the neutrino is defined as a particle with a right-hand helicity

$$\mathcal{H} = (\sigma \cdot \rho) = +1;$$

the antineutrino as a particle with a left-handed helicity

$$\mathcal{H} = (\sigma \cdot \rho) = -1.$$

The two-component theory introduces certain relationships between the coupling constants of the beta interaction. As far as nuclear beta-decay phenomena are concerned, the two-component neutrino theory gives a picture which is consistent with all the experimental evidence on parity nonconservation. Konopinski also discussed the problem of lepton conservation in beta-decay. It seems that this conservation law is not violated. One of the most important questions which now remains to be answered by experiments is the problem of invariance of the weak interaction Hamiltonian under the time-reversal operation.

The experimental evidence of nonconservation of parity and charge conjugation in beta-decay was the subject of the next lecture, which was given by C. S. Wu (Columbia). The lecture comprised a survey of the experimental development concerning parity nonconservation. Ever since the historic investigation of Wu *et al.* (January 1957) which established the fact that parity as well as charge conjugation is not conserved in beta-decay, data have been amassed at a tremendous rate.

The original experiment of Wu *et al.*, which was performed at the National Bureau of Standards, consisted of polarizing the electron emitter cobalt-60 by means of low-temperature techniques and observing the intensity of beta radiation in the direction of the spin vectors of the polarized cobalt-60 nuclei and in the opposite direction. A large asymmetry of the beta ray intensity was observed; only about half as many electrons were found to be emitted in the direction of the nuclear spin as in the direction opposite to the spin vector. The presence of this asymmetry gave conclusive proof of the violation of parity conservation (P), and the magnitude of the effect also indicated that invariance under charge conjugation is violated (C).

Similar experiments with the positron emitter cobalt-58 showed the same result, except that the asymmetry is positive—that is, more positrons are emitted in the direction of the nuclear spin vector. In addition, it was verified that the asymmetry of the beta emission for electrons as well as for positrons is essentially proportional to $\beta = v/c$ (v = velocity of the beta particle). This experimental result is in agreement with the predictions of the two component neutrino theory. A very accurate determination of the momentum dependence of the beta asymmetry could, in principle at least, resolve the question of whether the beta interaction violates invariance under time reversal (T). If T is conserved, then CP is conserved on the basis of the Schwinger-Luders-Pauli theorem (TCP theorem).

Shortly after the nuclear polarization experiments, the observation of the circular polarization of the gamma radiation following beta-decay and the longitudinal polarization of electrons and positrons emitted in beta-decay corroborated the failure of parity conservation in weak interactions. Although some early experiments seemed to indicate a small longitudinal polarization of the beta particles in some cases, all the more recent measurements agree with a longitudinal polarization of degree $-v/c$ for electrons and $+v/c$ for positrons.

M. Deutsch (Massachusetts Institute of Technology) discussed the experimental methods which are being used to study the longitudinal polarization of positrons. All these methods make use of the dependence of the annihilation properties of the positron-electron pair on the state of the polarization of the positron. The angular correlation of the annihilation radiation of positrons stopped in magnetized iron can be employed to establish the longitudinal polarization of positrons, or a method can be used which is based on the difference which exists in the annihilation-in-flight rates for the $M=0$ and $M=1$ magnetic substates formed by the incident longitudinally polarized positron and the polarized electron partner in magnetized iron. Deutsch also discussed his and his collaborators' method of observing the circular polarization of annihilation radiation emitted by longitudinally polarized positrons which annihilate in flight.

A very elegant method of observing the longitudinal polarization of positrons is based on the measurement of the preponderance of $1^3S_{1,0}$ states of positronium over $1^1S_{0,0}$ states formed in a gas in a magnetic field. This observation yields directly the excess of positron spins opposed to the magnetic field over those parallel to it.

The various methods which are being applied to determine the longitudinal polarization of electrons were discussed by H. Frauenfelder (Illinois). The circular polarization of the bremstrahlung of electrons stopped in matter gives direct evidence of their longitudinal polarization.

In a quite different approach to the problem, use is made of the strong dependence of the electron-electron (Møller) scattering cross section on the relative orientation of the spins of the incident and target electron. At all energies, the cross section for such a scattering process is much smaller in the case where the two electron spins are parallel than in the case of antiparallel spins. Again, polarized electrons are available in magnetized ferromagnetic material, and the measurement of the longitudinal polarization of an electron beam consists in observing the intensity difference in the scattering of electrons on a magnetized iron foil for different directions of the magnetization. Also, various methods have been employed to convert a longitudinally polarized electron beam into a transversely polarized one (deflection in electric fields, scattering at 90°). The transverse polarization of the electrons can then be detected by elastic scattering on a thin foil of a high Z material (Mott scattering). A series of contributed papers on details of the above-mentioned measurements comprised the principal part of the remainder of this session.

A lecture on the measurement of beta spectra given by L. M. Langer (Indiana) closed the session. In his discussion, Langer presented evidence of slight anomalies in the spectra of indium-114, phosphorus-32, and yttrium-90. It is very unlikely that these deviations are attributable to Fierz type interference terms.

Angular correlation of nuclear radiations. The program of the next session consisted of papers on angular correlations of successive nuclear radiation. In the first lecture, R. M. Steffen (Purdue) presented experimental results on beta-gamma angular correlations. Ordinary beta-gamma directional correlation experiments on first-forbidden beta transitions (for example, potassium-42, gold-198) show an appreciable anisotropy, although the spectra were found to be of allowed shape. Precise beta-gamma directional correlation measurements on allowed beta transitions made it possible to give an upper limit for the pseudoscalar coupling constant C_P in terms of the tensor coupling constant C_T: $C_P < 5\, C_T$.

Beta-polarization gamma-directional correlation experiments, in which the transverse polarization of the beta particle with respect to the propagation directions of the gamma radiation and the beta radiation is measured, were described. Such a very small transverse polarization was observed in the decay of gold-198. The implications of this result for the invariance of the beta interaction Hamiltonian with respect to time-reversal was discussed.

Steffen also presented results of beta-directional gamma-polarization correlation experiments in which the circular polarization of the gamma radiation is observed. The circular polarization of gamma rays can be observed by studying the transmission through or the scattering on magnetized iron. The results of some of these measurements require the presence of appreciable interference terms (such as scalar-tensor or vector-axial vector interference, or both) in the beta-decay interaction.

Extra nuclear effects on angular correlations were the subject of the next two papers. A. Abragam (Saclay) presented a review of the general theory, using the density matrix formalism. The influence of the static interactions between external magnetic fields and magnetic moments of the nucleus or electric field gradients, or both, and the nuclear quadrupole moment were discussed. Nonstatic interactions can arise in liquids where the environment of a nucleus is continually changing and also as an aftereffect of the emission of nuclear radiation during the recovery of the electron shell from the preceding decay process. Abragam also considered the perturbation of a nuclear angular correlation by the application of radio-frequency fields.

In the next lecture H. Frauenfelder (Illinois) pointed out how quantitative measurements of the influence of extranuclear fields on angular correlations can be used to determine magnetic and electric moments of excited, short-lived nuclear states. The application of an external magnetic field causes a rotation of the angular correlation pattern. From the degree of rotation observed and from the known strength of the magnetic field, the magnetic moment of the intermediate nuclear state can be extracted. Experiments on electric quadrupole moments are much less informative, since no artificial electric field gradients of sufficient magnitude are available and since the field gradients in crystals must therefore be used.

Nuclear instruments and short lifetime measurements. The session on instruments of nuclear spectroscopy was opened with a survey by T. R. Gerholm (Uppsala) on applications of magnetic spectroscopy and coincidence techniques. Of particular interest was the description of a multichannel goniometer for making measurements of angular correlations. T. W. M. Du Mond (California Institute of Technology), in his talk on gamma ray measurements by means of crystal diffraction, discussed details of gamma ray spectrographs and the experimental methods used in the precise determination of gamma ray energies.

The last session of the conference was devoted to measurements of very short nuclear lifetimes. The subject of the first talk, presented by S. Devons (London), was the techniques involved in the measurement of lifetimes shorter than 10^{-10} second. Recoil methods are particularly successful in this range. In such methods the excited nucleus is produced with an appreciable recoil velocity (of the order of 10^8 to 10^9 centimeters per second), and the lifetime is related to the time scale determined by this recoil velocity and by the physical arrangements, such as distance moved by the recoiling nucleus or the Doppler shift in the energy as the recoiling nucleus is retarded in some stopping material.

In many cases the observation of nuclear resonance fluorescence provides quantitative information about the width, and consequently about the lifetime, of nuclear levels. The use of this latter method was presented by F. Metzger (Bartol Research Foundation). When using radioactive isotopes as the sources of the exciting gamma radiation, one has to compensate for the losses in recoil energy which occur in the emission and the absorption processes. Instead of the narrow gamma lines from radioactive sources, the wide Doppler-broadened gamma rays from charged particle reactions can be employed. The integrated cross section for resonance fluorescence, and with it the lifetime of a transition, can be determined in a scattering experiment or in a self-absorption experiment. In the next paper, S. G. Cohen (Hebrew University) reported on lifetime measurements of excited states produced after alpha decay, in which the recoil shifts of conversion electrons are used.

A garden party given by M. W. Weisgal, the chairman of the Weizmann Institute, provided a very pleasant conclusion of the official part of this most successful and enjoyable conference.

Many participants of the conference were impressed by the great interest displayed by the officials as well as by the population of Israel in matters concerning science. Not only was the conference broadly and prominently covered in the local press but there were always a considerable number of autograph-seeking youths waiting outside the conference halls. The fact that the delegates were invited to a banquet with David Ben-Gurion, the prime minister, and that a reception was given for them by the President of the State gave evidence of Israel's interest in the conference.

R. M. STEFFEN

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Society Elections

- American Association of Physics Teachers: pres.-elect, Francis W. Sears, Department of Physics, Dartmouth College; pres., Clarence J. Overbeck, Department of Physics, Northwestern University; past pres., Vernet E. Eaton, Wesleyan University; sec., Frank Verbrugge, University of Minnesota; treas., Sanborn C. Brown, Massachusetts Institute of Technology.

- Society of American Foresters: pres., George A. Garratt, School of Forestry, Yale University; v. pres., Henry J. Malsberger, Southern Pulpwood Conservation Association, Atlanta, Ga.; exec. sec., Henry Clepper, 715 Mills Bldg., Washington 6, D.C. The representative to the AAAS Council is Paul M. Dunn, St. Regis Paper Company, New York, N.Y.

- Astronomical League: pres., Russell C. Maag, Sedalia, Mo.; v. pres., Chandler H. Holton, Atlanta, Ga.; sec., Gene L. Tandy, 1805 North River, Independence, Mo.; exec. sec., Wilma A. Cherup, Pittsburgh, Pa.; treas., Norman C. Dalke, Seattle, Wash. The representative to the AAAS Council is Armand Spitz, Spitz Laboratories, Elkton, Md.

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- Instrument Society of America: pres., Robert J. Jeffries, Data Control Systems, Inc., Danbury, Conn.; past pres., J. T. Vollbrecht, Energy Control Company, New York, N.Y.; pres.-elect, and sec., Henry C. Frost, Corn Products Refining Company, 201 N. Wells St., Chicago 6, Ill.; treas., Howard W. Hudson, Skokie, Ill.; exec. dir., W. H. Kushnik, ISA, 313 6th Ave., Pittsburgh, Pa. The vice presidents are Edward C. Baran, Philip A. Sprague, John Johnston, Jr., Ralph H. Tripp. The representative to the AAAS is William A. Wildhack, National Bureau of Standards, Washington, D.C.

- The Mathematical Association of America: pres., G. B. Price, University of Kansas; sec.-treas., H. M. Gehman, University of Buffalo, Buffalo 14, N.Y.; associate sec., Lloyd J. Montzingo, Jr., University of Buffalo. The vice presidents are G. B. Thomas, Massachusetts Institute of Technology, and B. W. Jones, University of Colorado.

- Society of Economic Paleontologists and Mineralogists: pres., Gordon Rittenhouse, Shell Development Company, Houston, Tex.; past pres., R. V. Hollingsworth, Paleontological Laboratory, Midland, Tex.; v. pres., W. M. Furnish, Iowa State University; sec.-treas., Raymond E. Peck, University of Missouri, Columbia, Mo.

- Soil Conservation Society of America: pres., Russell G. Hill, Michigan State University; exec. sec., H. Wayne Pritchard, 838 Fifth Ave., Des Moines, Ia.; treas., H. F. Barrows, Hinsdale, Ill. The vice presidents are Alvin C. Watson, Soil Conservation Service, Washington, D.C., and E. L. Sauer, University of Illinois. The representative to the AAAS Council is Donald A. Williams, Soil Conservation Service, USDA, Washington, D.C.

Forthcoming Events

April

8–10. Electronic Waveguides Symp., New York. (J. Fox, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

9–12. National Council of Teachers of Mathematics, Cleveland, Ohio. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

9–14. Applied Psychology, 13th internatl. cong., Rome, Italy. (L. Meschieri, National Inst. of Psychology, Rome.)

10–11. American Inst. of Chemists, annual, Los Angeles, Calif. (L. Van Doren, AIC, 60 E. 42 St., New York 17.)

10–12. Biometric Soc., ENAR, Gatlinburg, Tenn. (T. W. Horner, General Mills, Inc., 400 Second Ave. South, Minneapolis 1, Minn.)

10–12. National Speleological Soc., annual, Gatlinburg, Tenn. (G. W. Moore, Geology Dept., Yale Univ., New Haven, Conn.)

10–12. Ohio Acad. of Science, annual, Akron, Ohio. (G. W. Burns, Dept. of Botany, Ohio Wesleyan Univ., Delaware.)

11. Vitamin B-12 Symp., New York, N.Y. (Miss J. Watson, 451 Clarkson Ave., Brooklyn 3, N.Y.)

11–12. Eastern Psychological Assoc., annual, Philadelphia, Pa. (G. Lane, Dept. of Psychology, University of Delaware, Newark.)

11–12. Montana Acad. of Sciences, annual, Missoula. (L. H. Harvey, Montana State Univ., Missoula.)

11–18. Horticultural Conf., 15th internatl., Nice, France. (Secretariat General, 84, rue de Grenelle, Paris 7^e, France.)

12. Society for the Scientific Study of Religion, New York. (L. Whitman, 297 Fourth Ave., New York, N.Y.)

13–14. American Soc. for Artificial Internal Organs, Philadelphia, Pa. (G. Schreiner, Georgetown Univ. Hospital, Washington 7.)

13–18. American Chemical Soc., 133rd, San Francisco, Calif. (R. M. Warren, ACS, 1155 16 St., NW, Washington 6.)

13–19. Federation of American Societies for Experimental Biology, annual, Philadelphia, Pa. (M. O. Lee, FASEB, 9650 Wisconsin Ave., Bethesda 14, Md.)

14–16. Automatic Techniques Conf. Detroit, Mich. (J. E. Eiselein, RCA, Bldg. 10–7, Camden 2, N.J.)

14–18. American Assoc. of Clinical Chemists, annual, Philadelphia, Pa. (M. M. Friedman, Lebanon Hospital, New York 57.)

14–18. American Assoc. of Immunologists, annual, Philadelphia, Pa. (F. S. Cheever, Graduate School of Public Health, Univ. of Pittsburgh, Pittsburgh 13, Pa.)

14–18. American Soc. for Experimental Biology, annual, Philadelphia, Pa. (J. F. A. McManus, Univ. of Alabama Medical Center, Birmingham.)

14–18. American Soc. of Biological Chemists, annual, Philadelphia, Pa. (P. Handler, Dept. of Biochemistry, Duke University School of Medicine, Durham, N.C.)

15–17. Gas Measurement, 34th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

16–25. Instruments, Electronics and Automation Conf., London, England. (Industrial Exhibitions Ltd., 9 Argyll St., London, W.1.)

17–18. Environmental Engineers, 2nd annual institute, New York. (Institute of Environmental Engineers, 9 Spring St., Princeton, N.J.)

17–18. Midwest Benthological Soc., annual, Madison, Wis. (K. M. Mackenthun, 453 State Office Bldg., Madison 2.)

17–19. Association of Southeastern Biologists, annual, Tallahassee, Fla. (J. C. Dickinson, Jr., Dept. of Biology, Univ. of Florida, Gainesville.)

17–19. Eastern Colleges Science Conf., 12th annual, Wilkes-Barre, Pa. (Mrs. E. Stevens, Wilkes College, Wilkes-Barre.)

18. Iowa Acad. of Science, annual, Des Moines. (C. H. Lindahl, Dept. of Mathematics, Iowa State College, Ames.)

18–19. Arkansas Acad. of Science, annual, Little Rock. (L. F. Bailey, Botany Dept., Univ. of Arkansas, Fayetteville.)

19–20. Eastern Sociological Soc., 28th annual, Philadelphia, Pa. (A. Van der Slice, School of Social Sciences and Public Affairs, American Univ., 1901 F St., NW, Washington 6.)

19–21. American College of Apothecaries, Los Angeles, Calif. (R. E. Abrams, Hamilton Court, 39th and Chestnut St., Philadelphia, Pa.)

19–25. Industrial Health Conf., Atlantic City, N.J. (IHC, Room 1313, 28 E. Jackson Blvd., Chicago 4, Ill.)

20–22. American Assoc. of Colleges of Pharmacy, annual, Los Angeles, Calif. (G. L. Webster, College of Pharmacy, Univ. of Illinois, 808 S. Wood St., Chicago, 12.)

20–22. American Soc. of Hospital Pharmacists, Los Angeles, Calif. (Mrs. G. N. Francke, 1812 Norway Rd., Ann Arbor, Mich.)

20–23. Chemical Engineering Conf., Canada-United States, Montreal, Quebec, (H. R. L. Streight, DuPont Company of Canada, P.O. Box 660, Montreal.)

20–23. Numerical Approximation Symp., Madison, Wis. (R. E. Langer, Mathematics Research Center, U.S. Army, Univ. of Wisconsin, 1118 W. Johnson St., Madison 6.)

20–25. American Pharmaceutical Assoc., annual, Los Angeles, Calif. (R. P. Fischelis, APA, 2215 Constitution Ave., NW, Washington 7.)

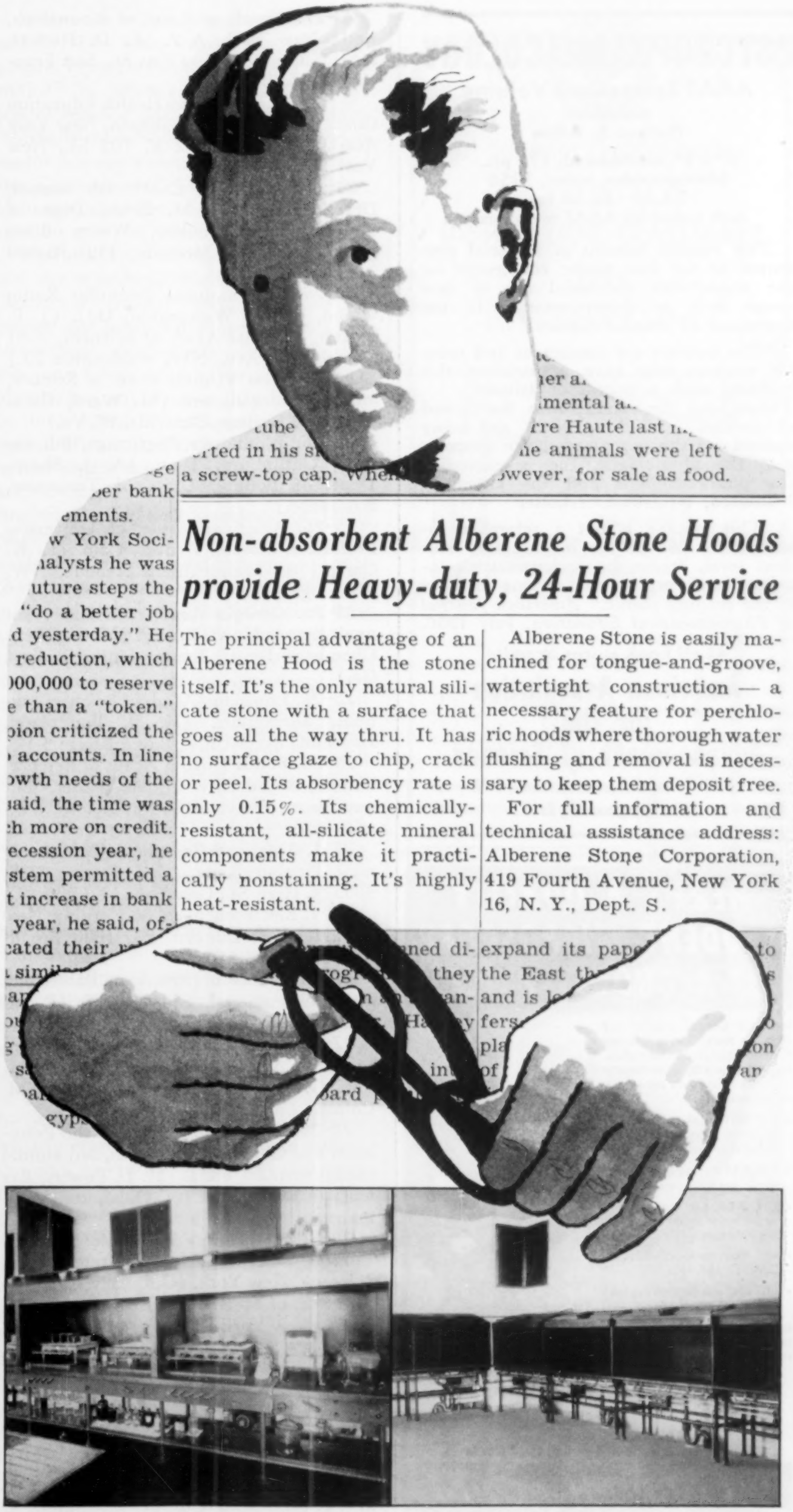
21–22. National Assoc. of Boards of Pharmacy, Los Angeles, Calif. (R. P. Fischelis, 2215 Constitution Ave., NW, Washington 7.)

21–23. American Oil Chemists' Soc., Memphis, Tenn. (Mrs. L. R. Hawkins, AOCS, 35 E. Wacker Dr., Chicago 1, Ill.)

21–28. American Industrial Hygiene Assoc., annual, Atlantic City, N.J. (G. D. Clayton, George D. Clayton and Associates, 14125 Prevost, Detroit 27, Mich.)

22–24. Electronic Components Symp., Los Angeles, Calif. (E. E. Brewer, Convair, Inc., Pomona, Calif.)

23–26. Internal Medicine, 5th internatl. cong., Philadelphia, Pa. (E. R. Loveland, 4200 Pine St., Philadelphia 4.)



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23–27. American Assoc. of Bioanalysts, natl., New York, N.Y. (L. D. Hertert, AAB, Suite 1049, 490 Post St., San Francisco 2, Calif.)

24–25. Eastern States Health Education Conf., New York (I. Galdston, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

24–25. Nutrition Conf., 4th annual, Detroit, Mich. (J. M. Orten, Dept. of Physiological Chemistry, Wayne State Univ., College of Medicine, 1401 Rivard St., Detroit 7.)

24–26. International Scientific Radio Union, spring, Washington, D.C. (J. P. Hagen, National Acad. of Sciences, 2101 Constitution Ave., NW, Washington 25.)

24–26. West Virginia Acad. of Science, annual, Morgantown. (M. Ward, Glenville State College, Glenville, W. Va.)

24–26. Wildflower Pilgrimage, 8th annual, Gatlinburg, Tenn. (A. J. Sharp, Dept. of Botany, Univ. of Tennessee, Knoxville.)

25–26. American Assoc. of University Professors, annual, Denver, Colo. (R. K. Carr, 1785 Massachusetts Avenue, NW, Washington 6.)

25–26. Georgia Acad. of Science, annual, Emory Univ., Emory. (M. T. Clark, Chemistry Dept., Emory Univ., Emory, Ga.)

25–26. Louisiana Acad. of Sciences, annual, Shreveport. (H. B. Boudreaux, Louisiana State Univ., Baton Rouge 3.)

25–26. South Dakota Acad. of Science, annual, Rapid City. (J. M. Winter, Botany Dept., Univ. of South Dakota, Vermillion.)

27–1. American Ceramic Soc., 60th annual, Pittsburgh, Pa. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

27–1. Electrochemical Soc., spring, New York. (H. B. Linford, ES, 1860 Broadway, New York 23.)

27–1. Society of American Bacteriologists, 59th annual, Chicago, Ill. (E. M. Foster, Univ. of Wisconsin, Madison 6.)

27–1. Southwestern and Rocky Mountain Div., AAAS, annual, Las Vegas, N.M. (M. G. Anderson, New Mexico A.&M. College, Las Cruces.)

28–29. Automatic Control in the Petroleum and Chemical Industries, 3rd annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

28–3. Engineering Societies of Western Europe and the United States, conf. (closed), New York. (C. E. Davies, American Soc. of Mechanical Engineers, 29 W. 39 St., New York 18.)

May

1–3. American Physical Soc., Washington, D.C. (K. K. Darrow, APS, Columbia Univ., New York 27.)

1–3. Kansas Acad. of Science, annual, Ottawa. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

1–3. Midwestern Psychological Assoc., Detroit, Mich. (D. W. Fiske, Dept. of Psychology, University of Chicago, Chicago 37).

1–8. American Soc. of Tool Engineers, 26th annual, Philadelphia, Pa. (ASTE, 10700 Puritan, Detroit 38, Mich.)

(See issue of 21 February for comprehensive list)

LETTERS

The editors take no responsibility for the content of the letters published in this section. Anonymous letters will not be considered. Letters intended for publication should be typewritten double-spaced and submitted in duplicate. A letter writer should indicate clearly whether or not his letter is submitted for publication. For additional information, see Science **124**, 249 *(1956) and* **125**, 16 *(4 Jan. 1957).*

Training of Science Teachers

In the December issue of *The Scientific Monthly* [**85**, 320 (1957)], Fletcher G. Watson advances a plan for the training of science teachers that may be suitable for teachers of physical science but is very inadequate for prospective teachers of biology. He proposes that the "biology teacher" have general inorganic chemistry (with qualitative laboratory), organic and quantitative chemistry, mathematics through the calculus, and introductory and atomic physics, plus geology and astronomy and probably meteorology, but only one year of introductory biology plus a semester of vertebrate physiology and one of plant physiology.

It does not seem to bother Watson that his "biology teacher" will have no intensive courses in botany and zoology and interrelated fields other than the two years mentioned. It bothers me very much. He thinks "Geology is important for considerations of paleontology and evolution, while astronomy involves atomic and nuclear physics and the 'big questions' of cosmogony." One can hardly deprecate these aims, but surely it would be more useful for our "biology teacher" to be well informed with regard to plant and animal biology and the integrating disciplines, so that he might consider the "big questions" of *biology.*

Watson thinks "genetics, cytology, and biochemistry are desirable but might be delayed to a fifth year or summer school." He seems to think that these are less relevant to the preparation of a biology teacher than astronomy, atomic physics, or geology. He does not even mention microbiology, morphology, or taxonomy.

It is not uncommon for physical scientists to lack appreciation of the scope of the biological sciences, but it seems doubtful that many would plan so scant a biology major. The de-emphasis of biological science has been so consistently practiced that, in the popular mind, the biological sciences are seldom thought of when the word *science* is used. Biologists have been especially lax in correcting the imbalance, as well as in pointing out to their colleagues in the physical sciences that the biological sciences are at least as broad in scope and as detailed in depth as the physical sciences.

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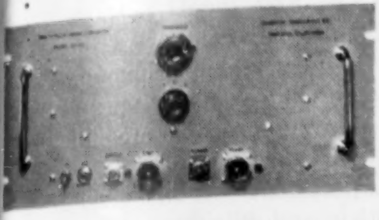

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There are other phases of Watson's article that seem regrettable. For example, he argues against the "good solid major" in science for the secondary school teacher, for, among other things, "Already those with a strong but narrow major are too attractive to industry and the Government." Does this mean that he wants us to have teachers so ignorant that no one else will want them?

The attack on the "good solid major" and the repetitious invective against the "narrowly trained specialist" are of course not new, but more of the anti-intellectual propaganda that we have too long tolerated, and in consequence of which great damage has been done to the training of teachers and the education of our youth. It would seem to be the urgent responsibility of those who are concerned about the improvement of American education to reject the fallacious notion that a teacher can be too well educated in his subject and to insist that our teachers be more thoroughly and intensively trained in the fields that they are required to teach. We need teachers, at all levels, who can inculcate a real love of learning and an appreciation of the nature of knowledge, and who will inspire young minds to genuine scholarly activity and exploration of science. Such teachers will need more than survey courses in their chosen fields.

SYDNEY S. GREENFIELD
Rutgers University, Newark, New Jersey

Sydney Greenfield's letter merits a reply because it illustrates the traditional position and line of argument taken for years by those in special areas of science. I had anticipated comparable complaints from the chemists, the physicists, and the earth scientists because I had proposed a training program with some balance among several fields. There seems to be an unwillingness to look realistically at the responsibilities of science teachers actually employed in the schools and at how they are to be "trained in the fields they are required to teach." Certainly it is easier to contend that the pattern of courses offered for a departmental major is *necessarily* the best possible preparation for teaching science than to look realistically at the task required of teachers (whether we like it or not) and attempt to prepare them for beginning this important work. With Greenfield's first four paragraphs I might agree, except for the obvious misquotation regarding my suggested program of study, during the four undergraduate years, for a potential teacher of biology and general science. The actual statement was: "The biology-general science major should include organic chemistry, which is essential to an understanding of modern biology. Atomic physics would also be helpful, for radioisotopes are playing an increasingly important role in biological investigations. Some instruction in

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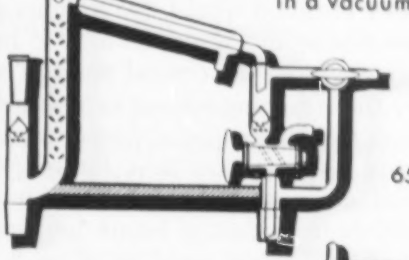

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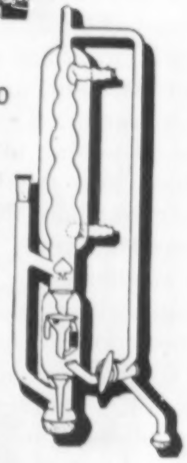

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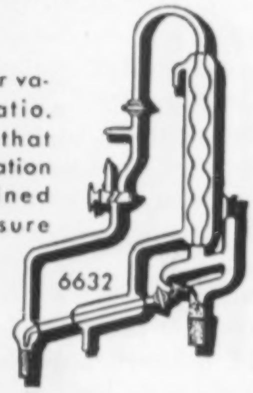

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geology and astronomy should be included. Geology is important for considerations of paleontology and evolution, while astronomy involves atomic and nuclear physics and the 'big questions' of cosmogony. These four courses, plus the four basics, would total 48 semester hours and still allow time for three half-courses or more in advanced biology. . . . The choice of courses for a 'most desirable' program is a difficult one, but it can be approached realistically in terms of the teacher's responsibilities."

In pargraph five Greenfield mischievously implies that teachers prepared according to an undergraduate program such as I outlined would "be so ignorant that no one would want them." He has, of course, missed the central point of my paper: that teaching science is an important task for which special preparation is necessary. To contend that future professional chemists need special training that differs from that of future biologists does not imply that one field of work is more important than the other; they are just different, and each requires special preparation. The same is true of science teaching in the secondary schools, which now involves over 65,000 teachers throughout the country. The past attempts to train future science teachers as single-subject majors fail on two accounts. First, they do not provide the schools with teachers adequately trained in *science*. Second, too many of the more promising potential teachers are lured out of the schools by much higher salaries currently available in industry and the government. On either basis, the schools and our children lose.

Greenfield neglects the appalling fact that, at present, only about 3000 new science teachers, qualified by whatever meager standards are set by the separate states, enter the schools each year, when some 7000 are needed. As a result, biology, which enrolls more students (1,200,000) than physics and chemistry combined, is frequently taught by individuals with far less preparation than even the two and a half to three years of biology I recommended. For example, in a recent addition to the many studies of teachers, M. O. Pella [*The Status of Science Offerings in Wisconsin in 1955–56*, Univ. of Wisconsin (1956)] found that in Wisconsin, in which state 83 percent of the 445 high schools enroll less than 500 pupils, biology was taught by 514 different individuals. Of these, 88 taught only biology. Ninety-nine others taught science (including biology) full-time, while 327 taught biology *and* other, nonscientific subjects. Of the 327, 114 also taught physical education, 77 taught social studies, and 67 taught mathematics. Probably, if the facts were available, New Jersey would present a comparable picture. These facts are not pleasant to contemplate, but they define the real problem, which academic wishful thinking will not overcome.

In the final paragraph, the emotionally loaded terms "repetitious invective" and "anti-intellectual propaganda" are not becoming a professor or *Science*. The damage to the training of teachers and the education of our youth has hardly been the result of the many proposals, which far exceed, in scope, the actual training of those who teach our children every day. The unwillingness of science professors to design effective training programs based on a knowledge of the facts has contributed materially to our present difficulties. The problem is serious, especially so now when near-panic is evoking extravagant public statements about the schools and those who teach in them. Answers to the question of what pattern of undergraduate study is most desirable for the future *science* teacher is squarely up to the collegiate departments which continue to supply most of the science teachers for secondary schools. Invectives may draw a chuckle, but they hardly constitute a thoughtful or realistic appraisal of a desperately serious problem, which must be met by the science faculties of our colleges and universities.

FLETCHER G. WATSON

Graduate School of Education,
Harvard University,
Cambridge, Massachusetts

Nuclear Tests and Ethics

In addition to the many social aspects of the radiation problem discussed in the AAAS symposium at the Indianapolis meetings, there is one that seems not to have been dealt with in detail, perhaps because it is obvious or because it appears unimportant. I have in mind the question whether nuclear bomb tests are in any sense permissible *from the viewpoint of science*.

There has been much talk during the last years about the formulation of a code of ethics for scientists. It should, however, be realized that much of this code already exists implicitly in the actual practice of science. In particular, scientists have accepted a rather stringent code of safety precautions in their research work. The individual researcher is still at liberty to endanger his own life in pursuit of truth. Any danger to his fellow workers or to the community at large is, however, sedulously guarded against.

Nuclear bomb testing is often talked about as involving risks. Thus, Willard Libby in his letter to Albert Schweitzer has spoken of the risk from world-wide radioactive fallout. It has become clear now, from genetic and medical studies, that it is not a *risk* but a *certainty* that every nuclear weapon tested will kill a certain number of people.

Harrison Brown, California geochemist, has put it this way: "We would not dream of lining thousands of people against a wall and shooting them down in order to test a new machine gun. But this, in effect, is what the U.S., the U.S.S.R. and the U.K. do when they test these fantastic new weapons. We do not know *who* the people are who are afflicted, but we know that with little question many people are killed as a result of these actions."

Experiments of this kind should be publicly and officially condemned by the scientific community as having no place in the pursuit of science whatsoever. A similar principle was enunciated by the Nuremberg courts in sentencing the doctors who performed experiments on concentration camp victims. The knowledge obtained from nuclear tests is tainted knowledge, knowledge obtained at the price of human individuals, belligerent or neutral, friend or enemy, innocent or guilty. If science will not proclaim its condemnation of such experiments, the verdict of history will do so in the future, and science will be condemned with them. As scientists we surely have learnt that the pursuit of knowledge cannot be the ultimate goal, but must always remain subservient to human values.

If scientists condemn such tests as having no place in science, the only justification for the tests remains that of military necessity. We are told that the "risks" of radiation damage must be weighed against the risks of exposure to Communist domination. If these are in effect the only alternatives, the West is morally doomed. If the high ideals of democracy can only be defended through the indiscriminate spreading of leukemia, then it may be asked whether democracy is worth the price. But why have we so slavishly accepted the dogma that there are no alternatives?

Some months ago the British Government issued a White Paper in which it concluded that Great Britain could not be defended militarily against nuclear attack. Commander Stephen King-Hall, noted news commentator, drew attention to the obvious implication—namely, that British subjects must develop nonmilitary means of defense against Communism. Such a path will become more and more necessary in this country also as technical knowledge advances. Could the scientific community, in order to preserve its own integrity, call on our government to proceed speedily with the exploration of paths, no matter how novel, by which both Communism and genetic deterioration might be avoided?

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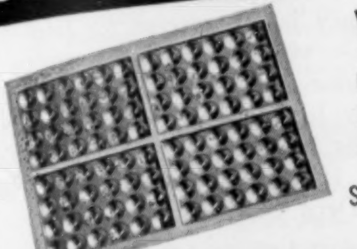

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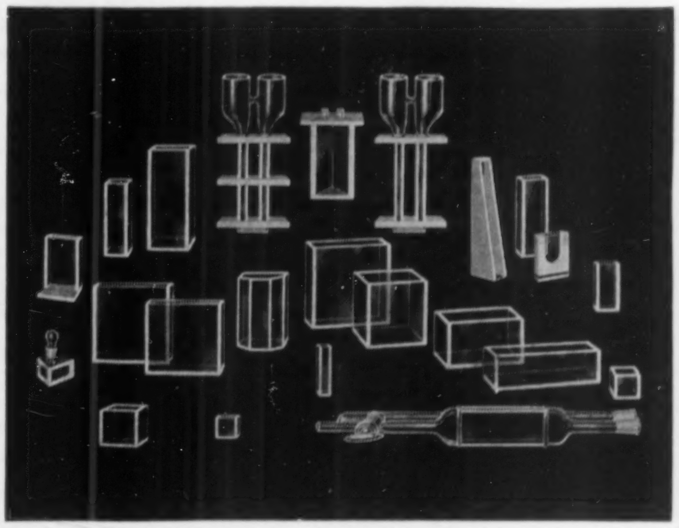

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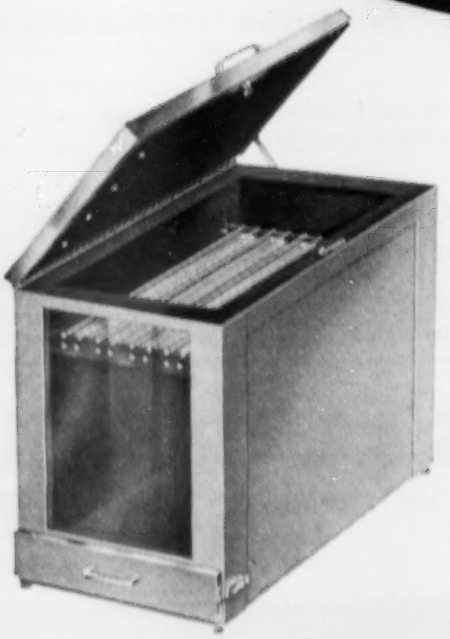

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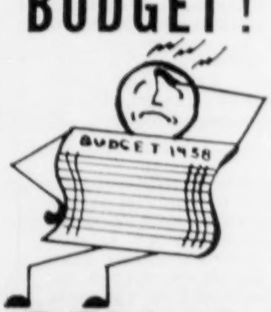

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